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ELEVENTH SESSION

MADRID : 5-15 MAY 1930

GENERAL PROCEEDINGS

2nd Section : LOCOMOTIVES AND ROLLING STOCK

INAUGURAL MEETING

6 May 1930, at 9 a. m.

PROVISIONAL CHAIRMAN : MR. DORPMÜLLER, MEMBER OF THE PERMANENT COMMISSION OF THE ASSOCIATION.

The Chairman (in German). — The Permanent Commission has requested me to inaugurate the meetings of the 2nd Section.

The problems which you have to study, Gentlemen, relate to both steam and electric locomotives and to metal carriages : they deal with one of the most important branches of the railway service. The competition between the steam and the electric locomotive continues with noble rivalry. I am tempted to compare it to the rivalry between lighting by gas and lighting by electricity.

Shortly before leaving Germany, I had the pleasure of becoming acquainted with an entirely new type of high pressure locomotive, but the future alone can show what results it will give..

So far as the use of metal carriages is concerned, America has led that movement for some time.

It is not my province to enter into technical details and I, therefore, hand over the presidency of the section to my

colleague **Mr. Wechmann**, Reichsbahndirektor, and trust that from your labours you will take home the most fruitful results.

The Permanent Commission also suggets as principal Secretary of the Section, **Mr. Chantrell**, Engineer of the Belgian National Railway Company. *(Applause.)*

Messrs. Wechmann and Chantrell then assumed office.

The President (in German). — First of all we must proceed to appoint Vice-presidents.

I propose :

Mr. H. van Manen, Manager of the Netherlands Railways (Member of the Permanent Commission);

Mr. R. André, Chief Mechanical Engineer of the Madrid to Saragossa and Alicante Railway;

Mr. M. Weiss, Chief Engineer of the Swiss Federal Railways.

Mr. J. de Fontes Ferreira de Mesquita, General Manager of the Portuguese Railway Company.

The section showed its approval of these nominations with applause, after which, as proposed by the President, the remaining staff of the section was nominated, and a provisional agenda drawn up.

[621. 132.8]

QUESTION V.

LOCOMOTIVES OF NEW TYPES; IN PARTICULAR TURBINE LOCOMOTIVES AND INTERNAL COMBUSTION MOTOR LOCOMOTIVES.

Construction, efficiency, use and repair.

Preliminary documents.

1st Report (Belgium, France, Italy, Portugal, Spain, and their Colonies), by Mr. Cossart. (See *Bulletin*, November 1929, p. 2397 or separate issue No. 35.)

2nd Report (British Empire, China, and Japan), by Mr. R. E. L. Maunsell. (See *Bulletin*, September 1929, p. 1563 or separate issue No. 19.)

3rd Report (other countries, except America), by Mr. P. Koller. (See *Bulletin*, April 1930, p. 1259 or separate issue No. 74.)

4th Report (America), by Mr. A. Lipetz. (See *Bulletin*, March 1930, p. 863, or separate issue No. 67.)

5th Report (Germany), by Prof. H. Nordmann. (See *Bulletin*, January 1930, p. 259, or separate issue No. 56.)

Special Reporter : Mr. P. Koller. (See *Bulletin*, May 1930, p. 1383.)

DISCUSSION BY THE SECTION.

Meeting held on the 6 May 1930 (morning).

Mr. WECHMANN in the Chair.

— The meeting opens at 9.30 a. m.

The President (in German). — All the reports drawn up for our section have been inspired by three considerations, the first of which is the *safety of the service*. The railway is bound to safeguard the life and health of its passengers and employees. That is why, for example, all the vehicles must be constructed so as to be capable of running with the maximum of safety at the high speeds required at the present time.

The second point of view is low operating cost on the expenditure side, that is to say, the reduction of the working expenses. This consideration exerts its influence, for example, on the construction of the locomotives, the aim of which is to reduce as much as possible the con-

sumption of energy for a given output of tractive work.

The third point of view is economical operating on the receipts side. The efforts made in this direction with the object of stimulating traffic are reflected in the comfort and rapidity of the journeys, as well as in the frequency of the trains; they have become particularly necessary on account of the considerable development in the use of automobiles.

It is not easy to satisfy to an equal degree the three conditions arising out of these considerations. If, for instance, particular importance is attached to improving the passenger coaches, the achievement of this desideratum will most frequently result in an increase in the working expenses. In studying the construction of the vehicles, therefore, it is necessary to keep the balance between the different factors in order to arrive at an acceptable solution.

Owing to the short time at our disposal, I must ask you, Gentlemen, to confine yourselves to the considerations which I have just explained. Let us now begin the discussion of Question V.

I shall ask Mr. Koller, the *Special reporter*, on this question, to speak.

Mr. Koller. — Gentlemen, it is due to the excellent reports presented by Messrs. Cossart, Maunsell, Lipetz and Nordmann that I am in a position today to give you a brief review of the present position as regards locomotives of new types. I must rely upon your indulgence for any imperfections which this summary may contain.

The locomotives of new types throughout the entire world consist of only a few units which it will be easy to enumerate: this number, however, is increasing rapidly. Up to the present, all these new type locomotives may be regarded as trial locomotives. The reason which has induced the builders of several countries, more particularly of Switzerland, Sweden, Germany, the United States of America, Great Britain, Italy, Russia, Austria, etc., to search for a new type of locomotive has evidently been the rather mediocre efficiency of the present locomotive as compared with stationary steam engine plants.

As is well known, this efficiency depends upon the conditions in which the locomotive works, but even the maximum efficiency, in the optimum conditions does not exceed about 8.5 % for locomotives of normal post war design.

It is true that it has been appreciably increased in the last few years for locomotives of improved construction in which superheating is carried to about 400° C. (752° F.). In this case, as we learn from Mr. Wagner's excellent report relating to Question VI, the maximum efficiency may attain 9 to 10 %.

However, this maximum efficiency, and even the entire curve of the total efficiency of the locomotive, while characterising the locomotive as an engine, does not provide us with any adequate basis for comparisons of costs between two types of locomotives, for example, in the case under consideration, between the locomotives of the new types and the comparable locomotives, that is to say, under the same conditions of service as of the usual type. For the purpose of this comparison of costs it would be necessary to understand the notion of efficiency in a much wider sense by taking into account all the expenses relating to the type of locomotive and referred to the useful work performed by it in actual service on the railways. When stated in this broad manner, however, the question becomes fairly complicated even for locomotives of the usual type. It is still

more difficult to examine from this point of view locomotives of new types, with which the experiments are necessarily small in number and for which certain data, for instance those concerning the costs of maintenance, are practically non-existent.

Nevertheless, the report by Mr. Lipetz provides us with a very interesting comparison between the internal combustion shunting engines and the steam locomotives utilised for the same purpose on the railways of the United States. We will return to this point later.

The other reporters have been forced to restrict themselves to a rougher comparison, limited to a few characteristic points which allow of a more or less approximate appreciation of the qualities of the new types of locomotives.

The construction of the various new types differs profoundly and perhaps it will be useful in the first place to attempt a certain classification of the new types of locomotives.

First of all, two broad categories may be distinguished among the new locomotives, namely, steam locomotives and internal combustion engine locomotives.

As regards *steam locomotives*, two principal means have been selected for improving the ratio of the heat energy of the fuel burnt in the locomotive to the mechanical energy recovered at the draw bar hook. The first has been to lower the final temperature of the thermal cycle of the steam engine by condensing. This has resulted in the use of the steam turbine instead of the usual piston engine, the cylinders of which become too large for the limited space available on the locomotive.

The steam turbine having once been introduced in this way on the locomotive, attempts have recently been made to use it even without condensing by utilising it on locomotives which exhaust to atmosphere.

The second means consists in raising the initial temperature of the thermal cycle by adopting high steam pressures and a particularly high superheat temperature. This method of procedure has led constructors to abandon the classical locomotive boiler and to replace it by a water-tube boiler.

Obviously, the two principles may be combined by using simultaneously condensing and high pressures.

Consequently steam locomotives can be divided into high pressure and low pressure locomotives. The limit is not quite precise but 25 atmospheres (355 lb. per sq. inch) may be chosen as an approximate limit. This, in fact, is the highest working pressure which we may expect to use in a boiler of the classical type.

Mr. Wagner, in his report concerning Question VI, does indeed mention that the Reichsbahn is at present considering the construction of two locomotives rated at 25 kgr. per cm^2 (355 lb. per sq. inch) and fitted with the usual type of boiler.

We also know that the turbine locomotive of Messrs. Maffei of Munich is provided with a boiler of the usual type rated at 22 kgr. per cm^2 (313 lb. per sq. inch). So far, this boiler appears to have given satisfactory results.

In this way, the term « high pressure » may be reserved for pressures between 25 and 225 atmospheres (335 and 3 200 lb. per sq. inch), the pressure of 225 atmospheres being the critical pressure. Pressures below 25 atmospheres, for which the boiler of usual construction suffices are only low pressures in this conception. Pressures exceeding 100 atm. (1 422 lb. per sq. inch) may be termed « extra-high pressures ».

Given these principles, the new types

of steam locomotives constructed or designed up to the present, may be arranged in the following categories :

1. *Turbine locomotives having the usual type of boiler* (low pressure).

This category comprises in the first place condensing locomotives and in the second place locomotives exhausting to the atmosphere.

Condensing turbine locomotives having the usual type of boiler may be subdivided into those which use turbines alone as engine and those which use the piston engine in combination with the turbine.

The majority of the turbine locomotives, constructed up to the present, condense. In particular, these are the four Ljungström locomotives, two of the Swedish State, one of the Argentine State Railways and one built in England, then the Zoelly locomotive built by the firms : Swiss Locomotive Works at Winterthur, and Escher, Wyss and Co. at Zurich, in Switzerland, the Zoelly-Krupp and Maffei locomotives in Germany, the Belluzo locomotive in Italy, as well as the locomotives designed by the French group of builders on the Ljungström principle and on the Zoelly principle, and mentioned in Mr. Cossart's report.

Among the locomotives having turbines alone and exhausting to the atmosphere are the two locomotives recently ordered by the Oxelösund - Flen - Westmanlands Railway from the Ljungström firm of Stockholm, Sweden.

The class of combined piston and turbine steam locomotives is only represented by one engine built by Messrs. Henschel & Sons of Cassel, the description and the test results of which are given in Mr. Nordmann's report.

2. The second large category of steam locomotives of new types are *the high pressure locomotives*, having a boiler of the new type with water tubes and either exhausting to atmosphere or condensing. The former use the piston engine and the latter the turbine.

The high-pressure piston locomotives in particular are : that of Winterthur, Switzerland, rated at 60 atm. (853 lb. per sq. inch) ; that of Schmidt-Henschel, Germany, which has the same pressure and that of the Löffler-Schwartzkopff type, Germany, pressed at 120 kgr. per cm^2 (1 706 lb. per sq. inch), the new locomotive of the London & North Eastern Railway, England, with a pressure of 450 lb. per sq. inch, as well as that of the London Midland & Scottish Railway, pressed at 63 kgr. per cm^2 (900 lb. per sq. inch) which corresponds to the Schmidt-Henschel principle, and the locomotive recently designed for the Reichsbahn, of the compound four-cylinder 2-6-2 type mentioned in Mr. Nordmann's report.

Among the high pressure locomotives must be mentioned those of the « Sentinel » type mentioned in Mr. Maunsell's report.

The high pressure turbine locomotives are, in particular, that of the Krupp firm, rated at 60 atm. (853 lb. per sq. inch) and that of Benson-Maffei, which generates steam at the critical pressure of 225 atm. (3 200 lb. per sq. inch) the pressure at the turbine being 180 atm. (2 560 lb. per sq. inch).

I must point out that we have no report dealing with the American high pressure locomotives or condensing locomotives, the report by Mr. Lipetz being confined to internal combustion engine locomotives (1).

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(1) See *Bulletin of the Railway Congress*, July 1930, p. 1683 : Supplement to Mr. Lipetz's report, dealing with *turbine locomotives* and *locomotives with water tube fireboxes*.

What are the advantages and disadvantages of the new steam locomotives ?

As regards turbine locomotives with the boiler of the usual type, working with condensation, the principal advantages are as follows :

1. Relatively high maximum total efficiency.

The maximum total efficiency which has so far been reached by a steam locomotive is that mentioned in Mr. Nordmann's report and found during trials made with the Zoelly-Krupp locomotive on the German State Railways in 1928. Under uniform running conditions at an almost constant speed of 80 km. (50 miles) per hour, the power developed on the drawbar hook of the locomotive being about 1 250 H. P., the overall efficiency of this locomotive exceeded 12 %, the specific consumption per horse-power hour being only 750 gr. (1.68 lb.) of coal with a calorific power of 7 000 calories (12 600 B. T. U. per lb.), *i. e.*, 5 250 calories (20 830 B. T. U.) per effective horse-power hour. The maximum total efficiency as given by the Ljungström firm is a little less, being only 11.1 %.

2. Another advantage resulting from the condensing principle is the constant utilisation of the same water re-distilled. Thus, there is no scale deposited in the boiler.

3. The movement of rotation of the turbine being uniform, starting and running are smoother than with a Stephenson type of locomotive.

On the other hand the chief drawbacks are :

1. By suppressing the blast the automatic regulation of the draught and of the quantity of steam produced in the boiler in proportion to the speed of the locomotive is lost.

2. A great amount of more or less complicated auxiliary machinery is required, which takes up a lot of room and absorbs a considerable quantity of steam (18 to 33 % of the steam produced in the boiler of the Zoelly-Krupp locomotive, according to Mr. Nordmann's report).

3. As it is impossible to reverse the turbine a second turbine is required for reverse working (Zoelly, Zoelly-Krupp, Maffei engines, for example) or else a special transmission so that the engine can be reversed (Ljungström locomotive).

The turbine only attains its maximum power within very narrow limits of speed and at other speeds is less economical than the piston engine.

Taking into consideration the fact that the number of revolutions of a locomotive necessarily varies between zero and the maximum corresponding to the design of the locomotive, it will be seen that the advantage derived from the relatively higher maximum efficiency of the turbine locomotive can be notably reduced when starting and by reductions in speed on steep gradients. And this even more so by the fact that the auxiliaries, in part at least, have to work even while the regulator of the locomotive is shut.

On the other hand, the construction of the condensing turbine locomotive is much more complicated, heavier and more expensive. Mr. Maunsell points out that, for ten engines of the Ljungström type, the first cost would be about 70 % higher than that of a normal locomotive.

Under these conditions the saving due to condensing would seem to be obtained at too great a cost. Before a definite opinion can be given comparative results obtained in actual working must be awaited. Perhaps our colleagues from railways using turbine locomotives, particularly those of the Reichsbahn and the

Swedish State Railways will be able to give us additional information on this matter.

As regards the combined locomotive of Henschel & Sons, of Cassel, which has already been mentioned, and in which the Stephenson type of locomotive is supplemented by a tender with turbine motor utilising the exhaust steam from the piston engine, the trials mentioned in Mr. Nordmann's report have not given encouraging results.

The motor-tender locomotive, owing to its own larger resistance, requires for the same powers, up to 510 H. P. more coal than the normal locomotive. It is only beyond this power that the motor-tender locomotive becomes more economical, up to a maximum proportion of about 25 %. The first cost is much higher, and the upkeep expenses are greater.

Up to the present, we have no information regarding the atmospheric exhaust turbine locomotives built by the Ljungström firm. I believe these locomotives are still under construction.

The high pressure locomotives may reach a maximum efficiency which is appreciably higher than that of the usual type of locomotives. It would appear necessary, however, to carry at the same time the superheat temperature to a higher degree than the temperatures attained up to the present, the maximum efficiency corresponding to the combination of the principle of high pressures and a high superheat temperature and of the condensing principle. However, in this case, the advantage of a particularly high maximum efficiency is obtained at the expense of the difficulties already mentioned for the condensing turbine locomotive.

If condensing be left out of consideration we can on the other hand retain the steam piston engine, the qualities of which are better able to give a satisfactory transport motor than those of the turbine. Further the advantage of the automatic regulation of the output of the boiler according to the speed of the locomotive by means of the exhaust blast is not lost.

In making use of high pressures and very high superheat temperatures however, a certain number of the present parts of the locomotive have to be replaced by new designs.

From this point of view, it is particularly necessary :

1. To build a new type of boiler, the walls of which must be protected against any accumulation of heat and which must at least equal in efficiency, flexibility, safety and mechanical strength the present form of locomotive boiler;

2. To adapt the steam engine to the great range of temperature and to the qualities of high pressure steam;

3. To adapt the different parts and auxiliary apparatus of the boiler and engine (*e. g.* the boiler casing, the packings, the feed water pumps, etc., etc.) to the high pressures and temperatures employed.

With steam at high pressures, even when it is superheated, the saturation limit is very soon reached in the expansion. It is therefore expedient to superheat the steam again in the intermediate stages of expansion.

In order to satisfy these different requirements, various simple or more complicated means have been tried, and these have found their expression in the different types of construction utilised up to the present.

In order to avoid the accumulation of heat in the walls of the high pressure boiler, and the damage that would result

therefrom, the following are the chief precautions taken :

1. Use is made of purified feed water :

a) By the continual use of the same water : closed circuit of water and steam (high pressure part of the Löffler-Schwartzkopff locomotive and the condensing locomotives of Krupp and Benson-Maffei);

b) By treating the feed water before it passes into the high pressure boiler :

α by passing through a special heater at a high temperature (about 250° C. [482° F.], Winterthur);

β by passing it through a softener and a low pressure boiler (Schmidt-Henschel);

2. A good circulation of the water is assured, eventually — at particularly high pressures exceeding 100 atm. (1 422 lb. per sq. inch) — even of the steam enclosed in the high pressure boiler, and this by :

a) The natural feature of the difference in density between hot and cold water (lower pressure Winterthur boiler — Schmidt-Henschel heating boiler);

b) A pump which pumps back the heating steam (Löffler-Schwartzkopff);

3. Indirect heating can also be employed from the high pressure boiler :

a) By piping containing the heating steam (Schmidt-Henschel). In this case a heating boiler is needed with a higher pressure, which however can have a closed water and steam circuit and consequently be heated directly;

b) By introducing into the high pressure boiler a jet of superheated steam at the same pressure (Löffler-Schwartzkopff). In this case the superheater tubes are heated directly.

In order to superheat the steam again in the intermediate stages of expansion, low pressure superheated steam, produced in a low pressure boiler is added, for example (Schmidt-Henschel). In this system obviously part of the advantages of high pressures is lost by carrying out part of the work by steam produced in a low pressure boiler, *i. e.* under the same conditions as in an ordinary locomotive. New designs for this type of boiler for this reason greatly reduce the use made of the low pressure boiler.

In the Löffler-Schwartzkopff system only the *heat* obtained by the condensation of the high pressure steam, expanded to about 17 atm. (242 lb. per sq. inch) is used for heating the low pressure boiler. Therefore the heat is used in two ways, after the manner of compound locomotives, by using for carrying this heat, steam from two different sources. Even in this system therefore there are two distinct steam generators, one high pressure, the other low.

The principle of high pressure consequently results in certain complications in the construction of the locomotive. However these are much less than those involved by the principle of condensing. Nevertheless relatively simple designs will certainly be evolved. Even now valuable results can be obtained by fairly simple constructions, as is proved by the example of the Winterthur locomotive which has a single boiler and a simple expansion steam engine.

Up to the present the maximum overall efficiency reached by high pressure locomotives which have been tested (Winterthur, Schmidt-Henschel) is only 9 to 9.2 %, *i. e.* lower than that of the later locomotives of the ordinary type with

high superheat. In comparison with less recent locomotives of the usual type of construction, when compared with that of new types of engines, the coal consumption of the high pressure locomotives is about 30 % lower.

The high pressure atmospheric exhaust locomotives which do not require complicated auxiliary apparatus would seem to be the type likely to result — once initial difficulties have been overcome — in a new locomotive with higher efficiency than that of the usual type while retaining its other precious qualities as an excellent transport motor.

We now come to the second category of locomotives of new types : these are *the locomotives driven by an internal combustion engine :* the Diesel engine which is chiefly used for the rather more important locomotives.

It is a well known fact that the efficiency of the Diesel locomotive is particularly high : 32 to 35 % of the energy contained in the fuel is available at the motor shaft. From these figures however a deduction must be made not only of the losses between the motor shaft and the locomotive draw bar hook which can be 10 % or more, but above all account must be taken of the fact that the cost of the unit of heat energy in the naphta is much higher than the cost of the unit of heat energy obtained by burning coal.

To compare the efficiency of a locomotive using coal with that of one burning fuel oil, the efficiency of this latter must be reduced in proportion to the higher cost of fuel.

Not only does the Diesel motor, as developed already, require certain auxiliary equipment (source of energy for starting, etc.) but furthermore its characteristics, especially its small speed range makes it impossible to use it on a locomotive without certain supplementary apparatus (intercoolers, etc.), and in particular without some flexible coupling giving a few degrees of movement, between the motor shaft and the driving wheels of the locomotive.

For this reason the construction of a Diesel locomotive becomes more complicated, heavier and more expensive (by 50 to 100 %) than that of a steam locomotive of the usual type.

Nevertheless Diesel motors are used on railway vehicles in many cases already. Most of these are on rail motor coaches, like those of the Pampelune to St. Sebastian Railway in Spain, mentioned in Mr. Cossart's report, but even the number of small Diesel locomotives, generally with electrical transmission, is fairly large, for instance, the locomotives of the Tunisian Railways (Mr. Cossart's report), the Danish State Railways, certain Swedish railways, etc. in Europe, above all the petrol locomotives of the United States of America, which are mentioned in the excellent report of Mr. Lipetz. Diesel locomotives have even been built of medium power, about 500 H. P. and over, as for example, the Ansaldo locomotive of the Italian State Railways or the American locomotives (Nos. II, V, VI, VII of the report of Mr. Lipetz, of a power between 600 and 900 H. P.).

What particularly interests us here are the large Diesel locomotives which can haul the trains worked today on the main lines. Among such may be considered the following Diesel locomotives :

A. — *Diesel-electric locomotives.*

Electrical transmission which is perfectly flexible fits these locomotives for widely different railway services, even for shunting operations.

1. Diesel locomotives with electrical transmission, for goods services, No. 001

of the Soviet Railways, built in 1924 from the designs of Professor Lomonosov by the Maschinenfabrik, Esslingen, Germany. The Diesel motor was supplied by the Maschinenfabrik Augsburg-Nürnberg Company (M. A. N.); it has a maximum power of 1 200 H. P. This locomotive has undergone many trials; since 1925 it has been in service on the Soviet Railways.

2. Diesel electric locomotive, for goods services, of the London & North Eastern Railway, under construction; will be achieved by the transformation of an electric locomotive. This locomotive will have a Beardmore variable-speed Diesel motor of 1 000 H. P.

3. Diesel electric locomotive of the Japanese State Railways, 1 C 1 type, under construction in Germany, in the Esslingen shops. The Diesel motor will be supplied by the M. A. N.

4. Diesel electric locomotive of the Canadian National Railways which is composed of two 2 D 1 type units, each of 1 330 H. P. This locomotive is described in the report by Mr. Lipetz.

B. — *Diesel locomotives with hydraulic transmission.*

This method of transmission has been chiefly studied in England, Germany, Austria and Sweden; but the results have not come up to expectation. The efficiency of hydraulic transmission was not good enough and losses between the piston of the motor and the locomotive draw bar hook were 58 % of the indicated power. Only a few locomotives have been made by way of experiment and were of medium power, 400 to 500 H. P. at the most.

C. — *Diesel locomotives with pneumatic transmission.*

Pneumatic transmission has certain advantages. Among others, it enables the heat of the combustion gases and the cooling water to be used to reheat the working medium and so to increase the thermal output of the engine. On the other hand this kind of transmission presents many difficulties which have not yet been solved. Different systems have been designed (in Germany the Görlitzer M. F. system, the Zarlatti and Cristiani systems in Italy, etc.) and several trial locomotives have been built, of small and medium size.

The only large locomotive of this type has just been built in Germany: the Diesel locomotive with pneumatic transmission of the German State Railways. — This passenger locomotive, of the 2-C-2 type, was ordered in 1924 from the Esslingen Works, Germany. The Diesel motor is of M. A. N. construction; its normal power is 1 000 H. P.

This locomotive works with compressed air at 7 atm. (100 lb. per sq. inch), superheated by the heat of the exhaust gas to about 320° C. (608° F.).

Trials have been made which show that at this relatively low pressure it is possible to use air as the working medium without any fear of oil deposit or even of explosions of the lubricant.

It is easy to start up this type of Diesel locomotive and the compressor can be run before moving the locomotive itself.

D. — *Diesel locomotives with mechanical transmission.*

1. Diesel locomotive with mechanical transmission for goods services, No. 005 of the Soviet Railways. — This locomo-

tive of the 1-E-2 type with a maximum power of 1 200 H. P. on the motor shaft was built, in 1926, from the designs of Professor Lomonosov, by the firm of Hohenzollern, at Dusseldorf. After having undergone numerous trials this locomotive is now working regularly on the Soviet Railways.

This locomotive with mechanical transmission has given the maximum total efficiency of any Diesel locomotive, *i. e.* 29.4 %. The efficiency of the Diesel-electric locomotive is a little lower, about 25 %. It is hoped to get the same efficiency from the Deutsche Reichsbahn Diesel locomotive with pneumatic transmission.

2. Diesel locomotive, 1 C 1 type, with mechanical transmission, of the Japanese Government Railways; under construction in Germany at the Fried. Krupp Works. The Diesel engine will be supplied by the Germaniawerft, at Kiel.

Even when account is taken of the cost per unit of energy, the output of the Diesel locomotive is slightly greater than that of the best steam locomotives of the usual type.

By anticipating a longer average daily run for the Diesel locomotive, still more favourable results are obtained. In this connection, a detailed comparison of the results obtained by American companies will be found in the report by Mr. Lipetz, at least as regards the types of average importance.

The cost price of a Diesel locomotive is always notably higher, the construction heavier and more complicated, which has an unfavourable effect on the purchase price as well as on upkeep expenses.

The chief advantage of the Diesel is its high efficiency; this however depends upon the cost of fuel.

The future development of these locomotives must be awaited, as those that have been built up to the present are only « laboratories on wheels » according to a remark of Prof. Lomonosov, the chief introducer of this method of traction.

I have come to several conclusions :

« During the last ten years in the different European countries, especially England, Germany, Italy, Sweden, Switzerland and Soviet Russia many efforts have been made to develop a new type of locomotive for using in a more efficacious way the heat energy of the fuel.

« A certain number of condensing steam locomotives as well as high pressure locomotives and Diesel locomotives have been built and undergone trials. These trials have shown that certain initial difficulties are still to be overcome, usually fairly important ones, before any satisfactory construction can be arrived at. For this reason we are still at an experimental stage and up to the present the definitive type of the locomotive of the future has not been designed.

« Nevertheless new paths have been opened up. The large amount of preparatory work already carried through, and the experience already obtained will make it possible to realise — perhaps sooner than is generally expected — a new type of locomotive.

« Two of the reports presented to the Congress have drawn attention to the fact that such a development would be largely facilitated in Europe by the existence of scientific experimental stations for testing railway rolling stock.

« Taking into consideration the state of affairs which has been described I propose for acceptance the following recommendations :

« The Congress recommends the Administrations represented here :

« 1. To encourage efforts to create a

new type of locomotive, by facilitating in particular the initiative of locomotive builders in this matter.

« 2. To carry out methodically trials of locomotives of new types, of different designs, built by different makers and to publish the results of such trials systematically and as made.

« 3. To study the question of the opportunity and possibility of creating in Europe an international experimental station for scientific experiments on railway rolling stock. » *(Applause.)*

The President (in German). — I thank Mr. Koller for his splendid report.

In order to facilitate the discussion, I propose to subdivide the question as follows :

1. Condensing steam locomotives.

2. Extra-high pressure steam locomotives.

3. Internal combustion locomotives.

Mr. Nordmann, *Reporter* (in German). — The auxiliary appliances of turbine locomotives are more or less large consumers of energy. Also, the condenser cannot work as perfectly as that of stationary steam turbines because the quantity of cooling water is limited. For this reason also, the vacuum never attains the same value as in stationary plants.

The steam consumption of the turbine locomotives which have been built up to the present is a function of the time rather than of the distance, since the main turbine, during starting, as well as the auxiliary appliances consumes a large amount of steam. That is why the use of the turbine locomotive is only advisable at the present time in cases where starting and light running, such as the runs on leaving and returning to the shed, are relatively rare.

For a given rate of working, the saving of coal as compared with the consumption of a piston steam locomotive, has been for instance 40 %, but this saving is reduced by half, *i. e.*, to about 20 % when the locomotive is employed in a normal service of fast trains and when the additional mileage is not taken into consideration.

In addition, the turbine locomotive possesses very good practical qualities, the starting torque in particular being very high. Running is smooth because this locomotive has no reciprocating masses.

For some time, the Reichsbahn has allotted the Krupp locomotive to the normal express train service on the Hanover-Cologne line. This locomotive is also in favour with the employees. All these reasons ought to urge us to work in perfecting the turbine locomotive.

Sir Henry Fowler, London Midland & Scottish Ry. — On the London Midland & Scottish Railway we have carried out certain experiments with a turbine locomotive of the Ljungström type. We have not had many difficulties in respect of the main principles of the locomotive, but have had trouble with certain small items. I feel that to get the best work from a turbine engine it should run as far as possible at constant speed. This is, however, impossible with varying gradients and the different types of work that a locomotive is called upon to do from day to day. There is in addition the question of expense. A turbine locomotive is not so cheap in first cost, and this is especially so in respect of those fitted with a condenser. The condenser considerably increases the first cost, and it brings in a very delicate piece of mechanism. One feels that one may get a

great economy finally, but there is much work to be done before one will be able to properly adapt a turbine locomotive to the ordinary work of the day.

Mr. Onoe, Japanese Government Rys. (in German). — I should like to know how much more a turbine locomotive costs than a locomotive of normal type, including the price of the condenser, and also what is its first cost without condenser.

Mr. Nordmann (in German). — My reply to Mr. Onoe's questions is the following :

The Reichsbahn do not know yet, at least for the present, the cost of the turbine locomotive with condenser with which they have experimented, because a large number of modifications were made during its construction. Moreover, the Reichsbahn are hardly likely to build a turbine locomotive without condenser. For this reason the cost of the condenser has not been determined separately.

Secondly, as the condensing locomotive is still far from having reached the end of its evolution, the figures I have previously quoted should only be regarded as provisional values. I have just said that there can scarcely be any question of an atmospheric exhaust turbine locomotive, and so I regret that I am unable to reply to the second question.

Mr. Bals, Rumanian State Rys. (in French). — I should like to ask a question about the Ljungström turbine locomotive which has been mentioned.

In Professor Nordmann's report it is stated that one of the objections which has been raised against this type of locomotive consists in the fact that the vehicle carrying the boiler forms the front part of the locomotive, which does not correspond to the ordinary conception of safety when running through a curve at high speeds.

I should like to add that this conception is shared by many administrations, perhaps wrongly. However, according to the present way of thinking it is not considered advisable to place a driven vehicle in front of the driving vehicle.

I should like to know if there is any reason for objecting to the boiler being placed on the vehicle which is pulled instead of on the vehicle which is pushed, separating, if necessary, the driver from the stoker.

Mr. Nordmann (in German). — When we ordered the Krupp locomotive we considered the Ljungström locomotive to be an accomplished fact and for that reason we did not specially examine at the time its running qualities. Moreover, the Reichsbahn are bound to observe the Regulations concerning the construction and operation of railways, which lay down certain speed limits when a vehicle is pushed by a driving vehicle, for example in the case of a train with electric motor coaches.

Mr. Koller (in French). — I should like to add in reply to the remark made by Mr. Bals, that the arrangement in question could not be adopted without certain difficulties.

Perhaps the representatives of the Swedish Railways could enlighten us on this subject.

Several years ago, during a voyage in Sweden, I had occasion to travel on a Ljungström locomotive. The maximum permissible speed was 80 km. (50 miles). Up to that time the arrangement with the first vehicle pushed had had no drawbacks. On the whole, it is possible that

this arrangement does not offer the danger which is usually attributed to it.

However, the question is a very important one and could be studied more thoroughly. As Mr. Nordmann has pointed out, it bears some analogy to electric traction. At the present time, vehicles are frequently pushed in electrically hauled trains.

The President (in German). — Could any of the Swedish delegates give us more exact information regarding the Ljungström locomotive ?

— There was no reply.

Mr. Bianchi, Italian State Rys. (in French. — Professor Nordmann has told us that the condenser must be regarded as an indispensable member of the turbine locomotive.

On the other hand, according to what Mr. Koller has informed us, locomotives without condenser have been built quite recently in Sweden. It would be very interesting to know the reasons for abandoning the condenser and the results obtained, if possible.

Mr. Koller (in French). — I obtained this information from the *Organ für die Fortschritte des Eisenbahnwesens*. It is the Oxelösund-Flen-Westmanlands Railway which ordered two non-condensing atmospheric exhaust Ljungström locomotives from Nidquist and Holm, of Trollhättan.

I also remember that when I was in Stockholm, the Ljungström firm was already considering the question of non-condensing turbine locomotives. Unfortunately I have no detailed information.

Mr. Wagner, Deutsche Reichsbahn Gesellschaft (in German). — The relationship between the turbine and the condenser should never be lost sight of. The original idea was to increase the drop in pressure by equipping the locomotive with a condenser. From that moment the use of the steam turbine was indicated. If it is found later that the condenser is an undesirable accessory, which may be dispensed with in future, the principal reason which has led to the adoption of the turbine locomotive will disappear.

Mr. Bals (in French). — I should like to ask another question concerning the turbine locomotive. Has not the stoker to be always regulating the speed of the turbo-fan so as to adapt at each instant the intensity of combustion to the work demanded of the locomotive ?

Mr. Nordmann has said that turbine locomotives are not appreciably more difficult to drive than Stephenson locomotives of the usual type, and that the workmen were even very satisfied with them.

Does not the regulating in question demand rather considerable additional work on the part of the stoker, or is there an automatic appliance which regulates the speed of the turbo-fan in accordance with the power demanded of the locomotive at each instant ?

Mr. Nordmann (in German). — When we began to study the turbine locomotive, we said to ourselves that it would be necessary to employ as few automatic devices as possible, so as to have a free hand when driving the locomotive. But during the trial runs which were made with the assistance of skilled workmen and with a well instructed staff, we came to the conviction that it is not possible to obtain curves of as regular a shape as those of the current Stephenson type of locomotives. Hence the desire to employ a simple automatic device which

would ensure agreement between the consumption and the production of steam.

The President (in German). — It seems to me that we can now pass on to the question of high pressure locomotives. I should like to ask the delegates who wish to speak on this subject to be good enough to begin the discussion.

Mr. Nordmann (in German). — In high pressure locomotives, the drop in pressure is carried into the upper regions which has permitted the exhaust, a well proved device, to be retained. We began with a pressure of 60 kgr. (853 lb. per sq. inch) while the Americans were content with about 40 kgr. (569 lb. per sq. inch).

The Schmidt-Henschel locomotive is a double expansion locomotive, the low pressure part of which is fed by the addition of a fairly considerable quantity of steam to the receiver. The proportion at which the high pressure begins to contribute to the total power was fixed at about 60 %. There was no desire to dispense with the low pressure part because it contained a certain reserve in its boiler and also because the scale is deposited in this boiler.

We have already made numerous trial runs with this locomotive. The high pressure boiler has given full satisfaction; its walls are not exposed to the hot gases. Steam at a pressure of 90 kgr. (1 280 lb. per sq. inch) is introduced into it by means of a special system of coils. The success of the indirect heating is what may be called the good side of this locomotive.

What is less satisfactory is that the locomotive is very costly. It is therefore necessary to see whether the interest and depreciation due to the increase in the first cost are redeemed by the saving in energy. We have found that, compared with a new good Stephenson type of locomotive, there is not sufficient saving in coal to justify the additional expenses.

It must be concluded from what I have just said that in order to give good results, a high pressure locomotive ought to obtain the greater portion of its power from the high pressure part. The low pressure boiler is only justified because it forms the preheater and the scale separator. Thus, it is on these lines that the recent designs of the Reichsbahn are being developed. For an average power of the locomotive, the high pressure boiler is sufficient in itself. It is only for high powers that an addition of 15 to 20 % of low pressure steam is employed.

I am sorry that I am unable to provide further information on the *results obtained in service* with the first experimental locomotive. It was damaged in the first few weeks owing to a cylinder cover being impaired by leakage of water. However, it may at once be stated that indirect heating gives excellent results.

Mr. Renevey, Paris-Lyons-Mediterranean Ry, Algerian Lines (in French). — Mr. Nordmann has just said that a Schmidt-Henschel locomotive has had a cylinder broken in. Is this the first Henschel engine or the second? I understand from what I was told in Berlin that the Reichsbahn are building a Schmidt-Henschel engine in which almost the entire power is provided by the high pressure boiler. Has this engine been built or is it merely projected?

Mr. Nordmann (in German). — The details I have given relate to the first locomotive. The other two locomotives I have mentioned are in course of construction.

Mr. Bals (in French). — I should like to ask a question concerning the Schmidt-Henschel locomotive, the principle of which is evidently very interesting. The firebox of this locomotive is formed of a very large number of water tubes which intersect above the firegrate. This arrangement is reminiscent of the Brotan firebox. The Rumanian State Railways also possess a large number of locomotives equipped with the Brotan firebox, but the results obtained are not very satisfying from the point of view of upkeep expenses.

The points at which the tubes are expanded into the different receivers are a continual source of trouble. In all cases the upkeep expenses are appreciably higher than with the ordinary fireboxes. We have tried oil firing but the upkeep expenses were so high that we have had to abandon it.

It is true that in the case of the high pressure locomotive, the water circulating in the tube system is softened water, while the water, in the Brotan ordinary firebox is the usual water which at the most has been slightly softened by different appliances. It may be therefore that the results are much better owing to the absence of deposits in the tubes. As the locomotive has already been in service since 1927, Mr. Nordmann or Mr. Wagner may perhaps be able to furnish some information regarding the experience which has already been gained from the point of view of the repairs necessitated by the very large number of tubes forming the firebox.

Mr. Nordmann (in German). — There is no doubt that damage is avoided by feeding with condensation water. This assertion is confirmed by the fact that there have never been any leaks in the tubes of the Krupp locomotive.

— On the proposal of the President the meeting closed at 1 p. m., and the discussion was postponed till the following day.

Meeting of the 7 May 1930 (morning).

Mr. WECHMANN in the Chair.

— The meeting opened at 9.30 a. m.

The President (in German). — I declare the meeting open.

I shall ask the Meeting to continue the discussion on high pressure locomotives (Question V) which was deferred yesterday.

Mr. Koller (in French). — I should like to point out that there is a high pressure locomotive which almost satisfies the conditions indicated by Mr. Nordmann, that is to say, which utilises high pressure steam alone and in which the feed water is passed through a preheater for softening the water. This is the locomotive of the Winterthur firm.

It would perhaps be of interest if delegates who have witnessed similar trials in Austria and France would provide us with additional information on this subject.

As regards Austria, I had the occasion last year to visit the Austrian General

Directorate. A number of tests have been made there and have given satisfactory results. There have been tests with goods trains and passenger trains, in comparison with a locomotive of the ordinary type, series 629.

The final result was that the locomotive of the Winterthur firm gave a certain saving as regards the consumption of coal and water. As regards coal this saving is about 30 %.

But there have certainly been other tests, especially in France, and it would be desirable to have information regarding them also.

Mr. Renevey (in French). — The engineers of the French railways who went to Switzerland to study the Winterthur locomotive were very interested in it owing to its very great simplicity and, in order to be able to study it better, we borrowed this locomotive for a certain time for trials on the Est Railway.

The tests made in Switzerland were largely carried out with trains but we desired to employ a more precise method called the Polish or Grünewald method, that is, the locomotive running with fixed notch, fixed speed, with the limiting effort obtained by means of a brake-locomotive.

At that time, the tests did not give us satisfaction for the following reason. Above all too little steam could be produced. We had considerable trouble, the pressure fell very rapidly and never rose again. Apart from this, the engine, and the boiler especially, behaved very well.

We modified the exhaust slightly, in particular we used a Kylälä exhaust, but this was all done very quickly so that it was not quite perfect.

We had, however, already improved the blast to an appreciable extent and we ran one or two trial trains by the Polish method under fairly good conditions.

The locomotive was then taken back again by the Winterthur firm who were to inspect the boiler from the point of view of production.

We have just received an invitation from the Winterthur Locomotive Works to go and inspect the engine, and according to information we have received we should get continuously 700 to 800 H. P. at the draw bar hook without the pressure falling below 50 kgr. (711 lb. per sq. inch). The pressure should be maintained in a very regular manner between 50 and 60 kgr. (711 and 853 lb. per sq. inch). I am not acquainted with the modifications which have been made but we had the impression that the passage for the gases was much too wide so that there was no draught to speak of. We had great difficulty in getting more than 30 or 40 mm. (1 3/16 to 1 9/16 inches) of vacuum in what one could call the smoke box.

Apart from that, the engine behaved very well, except for a few minor adjustments to the mechanism.

The tests we made did not last long enough to permit us to draw any conclusions regarding the question of boiler scale, but we had the impression that none was formed in the boiler itself, but only in the preheater.

Mr. Wagner (in German). — We had the occasion to see the Winterthur boiler. The builder has solved the problem of the high pressure locomotive by means of sound technical methods. The whole arrangement has been designed in a remarkable manner and I cannot but congratulate the designer, Mr. Buchli. The steam production is divided systematically into a preheating carried out at a high temperature and the actual eva-

poration. With a courage worthy of admiration, the designer decided not to employ a closed circuit. He has succeeded in causing the boiler, fed with non-purified water, to remain free from scale.

As regards the use of the steam, Mr. Buchli has taken a course which was marked out for him by his large practice in the construction of electric locomotives. He has used a high speed steam engine and has transferred the torque to a jack shaft. As builders of steam locomotives, we have been terribly afraid of gears. It is fortunate that an experienced builder of electric locomotives has also tackled this problem. He expands the steam in uni-flow and single expansion. It is true that on this point I do not agree with Mr. Buchli because when the clearance volume is reasonable, single expansion would not seem to be practicable with an initial pressure of 60 kgr. (853 lb. per sq. inch). In all cases, the final pressures are about 5 kgr. (71 lb. per sq. inch) and very certainly at least 3 kgr. (42 lb. per sq. inch) whence a certain disproportion between the exhaust steam and the draught which it produces. In fact, the locomotive has three exhaust beats for one revolution of the driving wheels and these beats are so sharp that there is no longer any mean pressure in the exhaust column. It would seem, however, that the effect of the absence of this mean pressure is that the activity of the fire no longer corresponds, as otherwise, to the action of the exhausting steam. That is why I also believe that a modification of the blast pipe will not alter the situation in the least. The indications which have been collected would appear to show that, for the uni-flow expansion of the steam, it is necessary to fix lower values for the upper limits for the initial pressure. With the pressure which has been adopted it would perhaps have been preferable to have recourse to the compound system.

Mr. Weiss, *Vice-President* (in German). — To begin with, I shall refer to the detailed reports by Mr. Koller and to the publications relating to this question. The locomotive was built by the Winterthur locomotive works on their own initiative. It has been used by the Swiss Federal Railways not only for trial runs but also on regular service. The economies exceeded 30 % in comparison with an ordinary locomotive allotted to the same service.

If the locomotive has given less satisfaction in France, the reason is that the operating conditions were quite different.

Before I left Switzerland, several modifications were made to the locomotive in order to improve the air inlet of the firebox and to lower the temperature of the smoke box.

While the locomotive was being used on the regular service, a fairly large number of defects were naturally found, but these concerned the main parts, that is to say, the boiler and the steam engine, much less than the auxiliary appliances, and principally the feed pump, which very often refused to work.

Mr. Gresley, London & North Eastern Ry. — Reference has been made in the summary of the reports on high pressure locomotives to the locomotive which the London and North Eastern Railway has, the boiler of which has been constructed by Messrs. Yarrow, the shipbuilders. In designing this locomotive one of the most important points considered has been simplicity of the design. The difficulty with any form of water tube boiler is the prevention of scale, and, as in the

case of the Winterthur locomotive, the feed water is at a very high temperature before being introduced into the boiler. We are hoping to prevent the formation of scale on the evaporating tubes; the amount of scale found so far has been inappreciable.

Then there is the question of the loss of heat with a water tube boiler. In order to prevent this, an arrangement has been made by means of which the whole of the air required for combustion passes through a casing outside the tubes, and the temperature of the air which enters the grate is somewhere between 250° and 300° F. We can get as much air as we want when making 20 000 lb. of steam per hour.

I wish to ask whether the experience of those who have high pressure locomotives has led them to think there are considerable losses in the piping, cylinders, steam chests, etc., *viz.*, losses by radiation. With our locomotive we have increased the lagging to something like 4 inches in thickness, and would like to have the experience of others.

In connection with the cylinder proportions, it would be interesting to know, in the case of the Winterthur locomotive, whether the whole of the expansion takes place in one cylinder.

The President (in German). — I think that the discussion may be considered as exhausted as regards the exchange of opinions on the subject of the high pressure steam locomotive and we can now pass on to the question of Diesel locomotives. The different types of Diesel locomotives are principally distinguished by the mode of transmission of the power of the Diesel engine to the driving wheels. There are four types of transmission : electric, pneumatic, hydraulic and mechanical.

Sir Henry Fowler. — The London Midland & Scottish Railway Company has experimented with a high-speed Diesel engine with three coaches. The first cost is high, which is largely due to the transmission. No transmission employed is so simple as the electric. The train I speak of is expensive, owing to the fact that my Company is not able to run it more than 10 to 14 hours per day. If we could run, say, 20-22 hours per day, I think the extra service would make up for the extra cost, interest and depreciation, which we would have to expend to get on with our experiments.

The President (in German). — It is true that the electric transmission is distinguished by its great simplicity and great ease of regulation, but perhaps it is often too heavy.

Mr. Nordmann (in German). — It is certainly regrettable that the simplest transmission and at the same time the easiest to regulate is also the heaviest. As steam and electric locomotives are excellent from the point of view of ease of regulation, no large railway will consent to the conditions to be fulfilled in this respect by the Diesel locomotive being of a lower level.

Instead of the hyperbola representing the tractive effort, the curve obtained for the Diesel locomotive is step-shaped and is entirely situated below the hyperbola. The number of steps can only be diminished at the expense of simplicity.

Leaving shunting locomotives out of consideration, two modes of transmission only are acceptable for the large railways, which have reached a high degree of development, namely, in the first place, electric transmission and in the second place, pneumatic transmission. With

the latter, the steam locomotive may be taken as a model for the actual drive of the driving wheels. It is true that we shall then have a triple reproduction of the piston engine, namely, first of all in the Diesel engine, then in the compressor and finally in the motor. This transmission, however, is the only one which enables the heat of the exhaust gases to be utilised. The Reichsbahn are just carrying out the first tests with an engine of this type, but it is not possible as yet to give the results.

M. Reder, *Section secretary* (in German). — As regards the construction of Diesel locomotives, it is necessary to distinguish the types clearly according as to whether the locomotive is intended for a main railway or a secondary railway. In the latter case, the service is the same as for rail motor coaches. Also, mechanical transmission may very well be used for secondary lines with the lower powers which they necessitate, especially since the locomotive always runs over the same line, the section of which is known.

Mr. Munck, Danish State Rys. — I wish to say a few words about the economies achieved on the Danish State Railways. We have 10 locomotives (6 small —230 H. P., and 4 heavier — 450 H. P.) at present, which give satisfaction, and there are no difficulties with the transmission. On the Diesel locomotives there is only one man, whilst on the steam locomotive there are two. There are other advantages: we are able to run the Diesel engine much larger mileages per day than a steam engine — the conditions in Denmark being evidently different to those mentioned by a previous speaker. Our steam locomotives have a mileage of about 170 km. (106 miles) per day, whilst the Diesel engines run nearly double — some are even running 450 km. (280 miles) per day. There is a considerable saving in time, as no steam raising is required, nor coaling, nor water, in the morning; also the Diesel engines only have to fill up with oil once a day. We intend to go on building these locomotives up to, say, 900 H. P. I am of the opinion there is a great field for this type of locomotive, and do not think steam locomotives will be built in the future in Denmark with conditions as they are at present.

The President (in German). — Is there any one else who wishes to speak?

Mr. Stalder, Federal Posts & Railways Department, Switzerland (in German). — I should like to draw attention to the experiment made by a Swiss railway who had not the necessary funds for a general electrification and who replaced two steam locomotives by Diesel-electric rail motor coaches with a view to improving the operating conditions and to effect economies.

The first of these rail motor coaches was put in service in the middle of February, and the second at the beginning of May 1929. They were intended for pulling light passenger trains and their total performance up to the end of 1929 was 75 142 tr.-km. (46 692 train-miles), while the steam locomotives still in service have furnished during the whole of the same year 123 301 tr.-km. (76 617 train-miles) altogether.

For the full year, the consumption and cost of *fuel* amounted to :

Rail motor cars	0.813 kgr. per km. or	0.016 kgr. per tkm.
	(2.88 lb. per mile or	0.057 lb. per Engl. ton-mile).
	(1) 10.16 cts. per km. or	(1) 0.197 cts. per tkm.
	(1) (16.35 cts. per mile or	(1) 0.322 cts. per Engl. ton-mile).

(1) Swiss currency.

Steam locomotives	9.82 kgr. per km.	or 0.146 kgr. per tkm.
	(3.48 lb. per mile	or 0.526 lb. per Engl. ton-mile).
	(1) 49.14 cts. per km.	or (1) 0.728 cts. per tkm.
	(1) (79.08 cts. per mile	or (1) 1.190 cts. per Engl. ton-mile).

and for *lubricating oil :*

Rail motor cars	0.033 kgr. per km.	or 0.00065 kgr. per tkm.
	(0.117 lb. per mile	or 0.00230 lb. per Engl. ton-mile).
	(1) 1.86 cts. per km.	or (1) 0.0368 cts. per tkm.
	(1) (2.99 cts. per mile	or (1) 0.0602 cts. per Engl. ton-mile).
Steam locomotives	0.03 kgr. per km.	or 0.00045 kgr. per tkm.
	(0.106 lb. per mile	or 0.00162 lb. per Engl. ton-mile).
	(1) 1.39 cts. per km.	or (1) 0.0206 cts. per tkm.
	(1) (2.23 cts. per mile	or (1) 0.0337 cts. per Engl. ton-mile).

Operating on steam alone would have resulted, therefore, for the total of 198 443 km. (123 309 miles) in an expenditure of 100 000 fr. (1) for fuel and lubricating oils, while operating with Diesel-electric rail motor coaches alone would have cost in round figures 24 000 fr. (1), thus allowing of a saving of about 76 000 fr. (1), or in other words 76 %. Considering that this advantage was accompanied by others, such as saving of the fireman, motor vehicles always available for service, etc., it may be understood that the railway in question is very satisfied with the result of this trial.

The Diesel engine employed, which was obtained from the Sulzer Company, is a high-speed engine of about 800 r. p. m. and a power of 250 H. P. The coach weighs 32 tons and has 48 seats. The cost of a rail motor coach is 175 000 fr. (Swiss).

Mr. Bals (in French). — I should like to ask how the trains hauled by Diesel locomotives are heated. I suppose that a steam boiler must be provided to ensure this heating. Under these conditions, is one employee sufficient for driving the locomotive, at least in winter ?

Mr. Munck (replying to Mr. Bals). — The boiler is either oil fired or heated by the exhaust gases from the Diesel engine — the feed is automatic.

Mr. Nordmann (in German). — The German Diesel locomotive with pneumatic transmission also comprises a boiler fired by oil for heating the train. The control of this boiler is automatic. The locomotive is so large and so complicated by the presence of the different piston engines and the large number of axles that two employees are necessary for driving it. The second employee is not required, therefore, for the heating alone.

Mr. Gresley. — The London & North Eastern has been interested in an engine of this sort, but the makers discovered

(1) Swiss currency.

that they were unable to fulfil the guarantees which they had given in respect to its performance. This engine which was 1 000 H.P. was going to cost three times as much as a steam engine of the same power. The question of maintenance appears to be a very important one. I think that engines of small power can be run with a certain amount of reliability, but with those of 1 000 H. P. considerable difficulties arise.

With regard to Mr. Munck's statement about the mileage run by the engines in Denmark, it is common for steam engines in England to run 500 km. (310 miles) per day, and there is no difficulty, I think in running 650 to 750 km. (403-466 miles).

Mr. Debize, Tunisian Ry. Co. (in French). — The Diesel-electric locomotive has been much discussed. We have two of them in service on our line and we are very satisfied with them.

One question which has not been examined thoroughly is that of the progress which has been made or which one may hope will still be made from the point of view of mechanical transmission.

Electric transmission has great advantages from the point of view of regularity of running and the results which may be obtained by getting out suitable workings, that is to say, by giving all the time with the electric motor the maximum power of which it is capable. In suitable workings we get a performance which may be called a maximum.

With mechanical transmission, necessarily, we must work by steps. Consequently, the performance from the general point of view ought not to be so good, but nevertheless, there are some very great advantages from the general point of view of the engine and from the point of view of cost in adopting mechanical transmission. At the present moment we do not know what improvements may be made to it in the future.

The President (in German). — What is the power of the Diesel engine of the locomotives in question ?

Mr. Debize (in French). — They are locomotives of 120 and 250 H. P.

Mr. Wagner (in German). — When it is a matter of small powers not exceeding about 200 H. P., mechanical transmission is obviously the lightest and simplest, and consequently the most reliable. For station shunting services, a power of 150 H. P. is often sufficient. On the other hand, for line locomotives, it must be at least 400 H. P. In this case, mechanical transmission loses its simplicity and also becomes very disadvantageous from the point of view of the weight. On the Russian locomotive of 1 200 H. P., the transmission gear is enclosed in a casing and weighs with the latter, and without the main coupling, about 22 tons.

Mr. Bals (in French). — I should also like to know whether in repair working with Diesel locomotives the repair costs of the engine itself are serious or not. I have heard of certain fairly frequent repairs to the fuel injection fittings.

Mr. Munck. — It is very difficult to reply to this question, as the small engines have only been running 3 years, whilst the large ones have only been running 6 to 12 months.

The President (in German). — As there is no one else who wishes to speak,

we may close the discussion. We have still to examine the conclusions with which Mr. Koller ends his special report and which he read to us yesterday.

— These conclusions appear on page 1390 of the May nummer of the *Bulletin*.

Mr. Nordmann (in German). — If I may be permitted to speak first of all on the 3rd recommendation, I should like to make a few remarks. In itself, an experimental station is very useful because the experiments are made independently of any railway line. But the results obtained in such a station are not conclusive, especially as regards the power developed at the draw bar hook, seeing that the experimental station cannot take into consideration either the air resistance or the resistance of the carrying axles. A test made on the line is alone able to fulfil these conditions.

It is true that a test of this type as regards the Commission proposed by Mr. Koller could be carried out on a line of some railway administration, only it seems to me that very serious difficulties would result. Two extreme cases may be imagined. The first case would be that of an administration desirous of testing a very novel construction. International Commissions sometimes show themselves to be particularly prudent. Should the administration in question be prevented therefore from testing the novel design ? In the second case, the difficulty consists in knowing what will be the attitude of the managing administration if it had to test a locomotive of a normal type which appeared to present some interest, at the same time as the International Commission was desirous of carrying out a test of a new type.

I should like to propose therefore that an international experimental station should not be erected but that a detailed and universally applicable questionnaire should be drawn up, in which would appear all questions relating to the tests.

Mr. Gresley. — I have listened with great interest to what Mr. Nordmann has said. In England a Committee has been appointed, and has come to certain conclusions, which are not yet published, in respect to the provision of a locomotive testing plant, or experimental station. The idea is that this should be used by all the railways so that any engines tested would be tested under similar conditions — when tests are made on the road, they are not under identical conditions, as the road, wind, weather, etc., vary from day to day. There is no such plant in Europe, although there are two or three in America, and I wonder whether it would be possible to have one international testing plant, or on the other hand one or two on the Continent and one in England. Some of the English railways have dynamometer cars, but what is also wanted is a car with the latest type of instruments, as it has been found that two dynamometer cars gave different results. I entirely endorse the conclusions which have been arrived at.

Mr. Wagner (in German). — In spite of all the sympathy which I feel for Mr. Koller's proposals, I should like to acquaint you with my objections against erecting an international experimental station. All the railway administrations have to put up a very hard fight with the motor car, and everywhere their receipts are not so good as formerly, so that in general there will be little inclination to enter upon expenses of this type. If the decision taken agrees with

Mr. Koller's recommendation, it will merely remain on paper. Moreover, it would be necessary to conduct interminable discussions on the subject of the choice of the staff, the site, construction, etc.

Mr. Renevey (in French). — The French railways are practically of the opinion of Mr. Gresley on the necessity of erecting experimental stations. In an experimental station, certain special points may be elucidated very quickly, and the results from one test to another are always clearly comparable.

We are also of the opinion that these laboratory tests ought not to prevent tests on the line being made. This being so, the French railways have decided to construct a similar testing station near Paris. I cannot dwell here upon the conditions under which it will be erected, but I shall be at the disposal of those delegates who require information.

I should also like to add purely on my own account that it seems to me to be preferable to have a series of experimental stations in the various countries so as to be able to compare the results obtained. In France, we have seven different railways. This is evidently a disadvantage from some points of view, especially that of unification, but on the contrary, from the point of view of tests it is an advantage. In fact, a test carried out in different places does not always give the same result, but in comparing tests which have given different results, the causes which were not perceived at the beginning, are often discovered.

That is why I consider that several experimental stations are indispensable and that one only would not at all fulfil the object we are seeking.

Mr. André, *Vice-president*. — It seems to me that summary 3 of Mr. Koller's special report deserves to be examined very closely.

Its principle is obviously excellent, and it is even of general or at least very wide application and in its application it goes much further than the question we are now considering.

In my opinion, it applies to all tests which are particularly expensive, and which are delicate by nature and by the conclusions which they are intended to establish.

The usefulness of an experimental station seems to me to be indisputable. It would exclude all the individual elements which are always present in reports drawn up by a Railway Company or by a representative of one of these Companies. It would always examine questions in a more general order, leaving out of consideration the foreign, individual or even parasitic elements.

For these reasons, I think that the establishment of an experimental station or stations would render great services to the companies by bringing to notice their most capable personnel; the latter could exchange views with one another which would certainly promote the study of the questions in a surer manner.

Another advantage is that of the facilities given to the builders, who could collaborate with the experimental station and also at the same time come into contact with the companies' representatives instead of having to work separately with each of them. The total expenses, those of the companies and those of the builders would also be reduced.

Finally, there is the question of first cost. Mr. Wagner has raised this question and he has pointed out all the difficulties; perhaps they are rather special to the period through which we are now passing, but in my opinion, this argument strengthens Mr. Koller's theory.

This meeting could at least take the general idea into consideration and express itself in favour of all the companies of one and the same country combining together as regards everything relating to researches and tests of a general order.

The President (in German). — I propose that we decide to leave the erection of the experimental stations to the different administrations. We could, however, recommend that the administrations should communicate their results to one another and that, on demand, they should also place their experimental stations at the disposal of foreign locomotives.

Mr. Gresley again recommended that experimental stations should be organised so that new types of locomotives in particular could be tested.

— Finally, on the general demand, a sub-committee was set up to examine on the basis of the discussion the proposals made by Mr. Koller and to formulate a definitive wording.

— The Section nominated Messrs. Koller (president), Gresley, Renevey and Wagner to be members of the sub-committee.

The President (in German). — I think that the discussion on Question V may be summarised as follows :

1. Owing to its great economic influence on the operating expenses of railways, it appears desirable to continue the study of the question of building economical types of locomotives. To attain this object, it would appear suitable to employ both locomotives having a greater range of expansion and locomotives with internal combustion engines.

2. All the experimental locomotives which have been built so far have given satisfactory results in one sense or another. It would therefore appear premature to exclude, as unfit for the desired object, any particular direction in which development is taking place.

3. So as to guide the subsequent development of the construction of locomotives in the right direction, it would appear to be sufficient to study carefully the relative effects of two antagonistic factors, namely, on the one hand the first cost, and on the other the cost of fuel and upkeep.

4. The Section considers it desirable to study continuously the question of perfecting new types of locomotives.

Meeting of the 8 May 1930 (morning).

MR. WECHMANN IN THE CHAIR.

The President (in German). — The sub-committee appointed to draw up a suitable wording for the summaries of Question V have completed their task. Mr. Koller will now oblige us by reading the new wording.

Mr. Koller (in French). — It runs as follows :

« The Congress recommends to the Railway Companies and Administrations present :

« 1. To encourage efforts to create new types of locomotives and to improve the current Stephenson type of locomotive by facilitating in particular the initiative of locomotive builders. »

That is in the main the first point proposed in the special report except that there is : « new types of locomotives » instead of : « a new type of locomotive ».

« 2. To develop further in particular the use of extra-high steam pressures and of the internal combustion locomotive. »

— That is a new point.

3. To carry out methodically trials of locomotives of new types and different designs built by various makers and to publish the results of such trials systematically and as made. »

— That is the 2nd point of the special report.

« 4. To co-operate with a view to the erection of locomotive experimental stations : the international collaboration of such stations would facilitate progress in scientific locomotive design. »

— That is a point which was mentioned yesterday.

The President (in German). — Does the Section agree to this wording ?

— The proposed wording was unanimously adopted.

— After discussing Question VI, the Section decided that these summaries shall also apply to Question VI.

DISCUSSION AT THE GENERAL MEETING.

Meeting held on the 10 May 1930 (morning).

President : Mr. José GAYTAN de AYALA.
General Secretaries : Messrs. P. GHILAIN and A. KRAHE.
Assistant General Secretaries : Sir Henry FOWLER, K. B. E., Messrs. P. WOLF and J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary*. — The summaries which are common to Questions V and VI have been published in the *Daily Journal of the Session*.

However, after these summaries had been drawn up, certain delegates asked for further discussion on different improvements of steam locomotives, regarding which no summaries had been formulated.

I have been able to come to an understanding with the President of the second Section, Mr. Wechmann, to propose that the findings which have been inserted in the journal be adopted at this General Meeting as regards Question V and that these summaries be considered valid for Question VI, but as regards the latter, these findings will be completed in the course of the next General Meeting.

Has any one any comments to make on what I have just said ?

— No comments.

The President. — The summary is worded as follows :

Summary.

« The Congress recommends to the « Railway Companies and Administra- « tions present :

« 1. To encourage efforts to create new « types of locomotives and to improve the « current Stephenson type of locomotive « by facilitating in particular the initia- « tive of locomotive builders;

« 2. To develop further in particular « the use of extra-high steam pressures « and of the internal combustion loco- « motive;

« 3. To carry out methodically trials of « locomotives of new types and different « designs built by various makers and to « publish the results of such trials syste- « matically and as made;

« 4. To co-operate with a view to the « erection of locomotive experimental « stations : the international collabora- « tion of such stations would facilitate « progress in scientific locomotive de- « sign. »

— This summary was approved by the General Meeting.

[621.134]

QUESTION VI.

IMPROVEMENTS IN THE STEAM LOCOMOTIVE.

Increased pressures and higher superheats. Improvements in the design of superheaters and parts connected with superheating. Feed water heating and air preheating. Improvement of valve gears.

Preliminary documents.

1st Report (France, Italy, Portugal, Spain, and their Colonies), by Mr. PARMANTIER. (See *Bulletin*, September 1929, p. 1573 or separate issue No. 20.)

2nd Report (other countries, except America, the British Empire, China, Japan and Germany), by Mr. Th. BALS. (See *Bulletin*, November 1929, p. 2421 or separate issue No. 36.)

3rd Report (America), by Mr. W. L. LENTZ. (See *Bulletin*, October 1929, p. 2113 or separate issue No. 30.)

4th Report (British Empire, China and Japan), by Mr. H. N. GRESLEY. (See *Bulletin*, November 1929, p. 2689 or separate issue No. 41.)

5th Report (Germany), by Mr. R. P. WAGNER. (See *Bulletin*, January 1930, p. 99 or separate issue No. 52.)

Special Reporter : Mr. R. P. WAGNER. (See *Bulletin*, May 1930, p. 1931.)

DISCUSSION BY THE SECTION.

Meeting of the 7 Mai 1930 (morning).

PRESIDENT : Mr. WECHMANN

The President (in German). — I would like Mr. Wagner to recapitulate briefly the most important points of his special report.

Mr. Wagner, *Special Reporter*, then gave a résumé of his report as published in the *Bulletin* of May 1930, page 1391.

The President (in German). — The report is open to discussion and I would ask speakers to be as brief as possible.

— Nobody desires to speak on Chapter I of the special report entitled : *Increase of steam pressure.*

The President (in German). — We

will now take Chapter II : *Steam superheating.*

Mr. Nordmann, Deutsche Reichsbahn Gesellschaft (in German). — The superheat is not constant, but increases considerably with the boiler output. In mentioning the degree of superheat, therefore, the corresponding load on the steam generator should also be given. The best method then, is to give the temperature obtained for the maximum output of the boiler, seeing that when the output of the latter is high, the temperature curve is almost horizontal.

— Nobody else desiring to speak on the subject of Chapter II, **the President** opened the discussion on Chapter III : *Feed-water heating.*

Sir Henry Fowler, London Midland & Scottish Ry. — I would like to say with regard to exhaust steam injectors, that the London Midland and Scottish Railway Company are so satisfied with them that they have made them standard for their future locomotives.

Mr. Parmantier, *reporter* (in French). The Paris Lyons & Mediterranean Company also have made numerous trials with exhaust steam injectors, but have not obtained any fuel saving exceeding 4 %, although the tests were supervised by locomotive inspectors.

Sir Henry Fowler. — We got about 7 % saving.

Mr. Bianchi, Italian State Rys. (in French). — We obtained about 3 % taken over the different locomotives.

Mr. Wagner (in German). — The saving depends on the pressure in the blast pipe, and increases with this pressure.

Mr. Bals, *reporter*. — Apart from the pressure of the exhaust steam of which Mr. Wagner has just spoken, the boiler pressure itself also plays an important part in the economical working of the exhaust steam injector.

This apparatus under normal conditions can only feed alone, *i. e.* without the help of live steam, up to a pressure of about 11 kgr. (156 lb. per sq. inch). The higher the working boiler pressure, the greater must be the amount of live steam taken, and obviously the more must the economy diminish.

In these circumstances, I consider that the figures of savings should always be taken in relation to the boiler pressure.

It is clear that for locomotives of the usual types, working at about 12, or 13 atmospheres (170 to 185 lb. per sq. inch), with simple expansion the economy is appreciably greater than for compound locomotives at 16 atmospheres (227 lb. per sq. inch).

On the Rumanian Railways locomotives with a pressure of 12 to 13 atmospheres have shown very appreciable savings, amounting to 6.7, and even 8 % in ordinary working. Furthermore in speaking of savings, the total economy, *i. e.* the first cost, and the cost of repairs, should be kept in mind.

When looked at in this way, and after adding together the whole of the economies obtained, I believe that on ordinary simple expansion locomotives the exhaust steam injector is a very economical apparatus, easily operated, and having many advantages, especially from the point of view of repairs.

The President (in German). — We

will now pass on to Chapter V, entitled : *Valve gears.*

Mr. Bianchi (in French). — In his special report, Mr. Wagner points out that it would be useful to have precise data of the results obtained with the Caprotti gear, much used in Italy.

During the trials we compared very efficient locomotives with ordinary valve gear with locomotives fitted with the Caprotti gear. The saving of coal was from 3 % to 5 % varying with the particular locomotive. In any case we can say that with the high price of coal in Italy, the use of the Caprotti valve gear is most interesting financially.

With coal at such high prices, a saving of 2 % is sufficient to pay for equipping an engine.

Mr. Wagner (in German). — When comparing the gears the same clearance volume should naturally be taken as a basis.

Mr. Bianchi (in French). — The comparative trials were made under equal conditions as regards this point.

A delegate. — What was the clearance volume in the two cases ?

Mr. Bianchi (in French). — It was 10 % during the trials in both cases. It should be noted that with the Caprotti valve gear the clearance can be reduced to 8 % but it should be clearly understood that during the trials it was 10 % so as to make the conditions equal.

Sir Henry Fowler. — My Company has 10 engines fitted with the Caprotti valve gear. First of all, one has been tested against an ordinary locomotive, whilst the next one has been fitted on to a similar engine, the boiler of which was of an improved type. I have figures with me showing the results of 12 months running. A total of about 400 000 miles has been run, and there has been a saving of 7.4 % of fuel by the use of the Caprotti gear.

Mr. Flobert, North of Spain Railways (in French). — On the North of Spain Railways, we tested two locomotives fitted with the Caprotti gear, and we obtained a saving under ordinary conditions of 5 % as compared with ordinary locomotives of the same type built at the same period, by the same maker and doing the same class of work.

The President (in German). — Chapter VI which comes next has for its title: *Draught and steam exhaust.*

Mr. Parmantier (in French). — I feel I must emphasize the importance which the Paris Lyons & Mediterranean Company attaches to being able to alter the size of the blast pipe nozzle.

We have made numerous trials and have found that when changing over from an open blast pipe to a reduced top, the power of the locomotive was considerably reduced.

Thus the H. P. may be 1 500 with a fully open blast pipe top and only 1 300 when the opening is reduced to the minimum.

It is of value therefore to be able to use different nozzle openings if only to meet the increased demand for heating the trains in winter.

Mr. Bals (in French). — I am of opinion that as regards the variable blast pipe, the staff plays a large part in the results obtained. Thus many railways prefer the fixed nozzle because frequently drivers, when wishing to get additional power from the engine, close the variable nozzle a little too much,

thereby increasing the back pressure in the cylinders, and consequently working the engine extravagantly : very often too great a demand is made on the boiler without any real necessity.

From the point of view of efficiency, I think that the variable nozzle is perhaps the better, but from the practical point of view, especially with staff of average quality, I think that the fixed nozzle is generally better.

The President (in German). — We will now take Chapter VII : *Miscellaneous questions.*

Mr. Parmantier (in French). — On the subject of compound expansion, the Deutsche Reichsbahn Gesellschaft was good enough to send the Paris Lyons & Mediterranean Company, the results of comparative trials between their compound and simple locomotives. The results showed that there was no great advantage in compounding. I should like to ask Mr. Wagner if on the compound engines, different ratios of the high pressure and low pressure valve gears were tried, or if only one ratio was considered sufficient.

Mr. Wagner (in German). — We did not alter the valve gear levers; the lap is so great that the most favourable results were obtained at medium cut-offs.

The President (in German). — The summaries embodying the results of this discussion will be considered tomorrow.

— The meeting ended at midday.

Meeting of the 8 Mai 1930 (morning).

President : Mr. WECHMANN

The President (in German). — I propose that the summaries adopted on Question V be also taken as applying to Question VI, both these questions dealing with steam locomotives.

A delegate. — What are the summaries for Question VI?

The President (in German). — The same as those adopted for Question V :

« The Congress recommends to the Railway Administrations present :

1. To encourage efforts to create new types of locomotives », etc.

Mr. Bals (in French). — I think it desirable to complete article 1 by adding « It is desirable to encourage efforts to create locomotives of new types, and to improve the ordinary Stephenson type of locomotive... »

The President at the request of Mr. Bals, had the summaries adopted for Question V read out, so as to show that the applied equally well to Question VI.

Meeting of the 12 Mai 1930 (morning).

President : Mr. WECHMANN

The President (in German). — At the full meeting held on the 10 May, it was decided that the summaries for Question V equally applied to Question VI, but to complete them as regards the latter by certain additions proposed by Mr. Bals.

A sub-Committee was formed to consider these additions, and the following wording which the Principal Secretary will now read to you, was agreed upon.

Mr. Chantrell, *Principal Secretary.* — The following are the supplementary summaries :

« Among the recent improvements which have taken place in steam locomotives of normal construction, special attention should be given to :

« *a*) Increase in the temperature of superheat, and

« *b*) The pre-heating of the feed water.

« Taking into account the numerous trials which have been carried out by many of the Railway Compagnies, and the experiences gained over many years, this Congress is of the opinion that :

« *a*) The temperature of superheat can, in practice, be taken to 400° C. (752° F.), special attention being given to lubrification and the method of steam distribution;

« *b*) That there are in service methods for pre-heating of water which are giving satisfaction.

« The Congress recommends the adoption of these two improvements on account of the important economies which can be realised from them. »

The President (in German). — Does the Section agree to this draft ?

Mr. Bals (in French). — I think it would be useful to have Mr. Parmantier's opinion on the subject of the superheat temperature.

In his report there appears to be some reticence with regard to the figure of 400° C. (752° F.). I think that is the only point to which exception might be taken; ought we to say 400° C. (752° F.) or 380° C. (716° F.) or ought we simply to indicate that 350° C. (662° F.) may be greatly exceeded, this being the figure generally accepted hitherto as the upper limit of superheat?

Mr. Parmantier (in French). — All the Administrations for whom I reported gave 400° C. as the best temperature, with the exception of the Paris-Orleans Railway, which said it would be better not to exceed 350° C. with simple expansion engines; the representatives of the Paris-Orleans Railway who are present, do not seem however, to have any objection to the figure of 400° C. being adopted for all locomotives.

Mr. Bals (in French). — Under these conditions we need not hesitate to give the figure of 400° C. (752° F.) as the desirable temperature.

The President (in German). — We can take the proposed draft as adopted. The meeting is closed.

DISCUSSION AT THE GENERAL MEETING.

PRESIDENT : MR. JOSÉ GAYTAN DE AYALA.
GENERAL SECRETARIES : MESSRS. P. GHILAIN AND A. KRAHE.
ASSISTANT GENERAL SECRETARIES : SIR HENRY FOWLER, K. B. E., MESSRS. P. WOLF AND J. M. GARCIA-LOMAS.

Meeting held on the 10 May (morning).

Mr. Ghilain, *General Secretary.* — Summaries common to Questions V and VI, have been published in the *Daily Journal of the Session.*

After these summaries had been drawn up, certain delegates asked that we should give further consideration to certain improvements in steam locomotives on which no summaries had been formulated.

I have arranged with **Dr. Wechmann,** President of the Second Section, that we should propose to the General Meeting, the adoption of the summaries given in the *Daily Journal*, on Question V, and that these summaries be taken as applying to Question VI, but as regards the latter, that our recommendations be completed at the next General Meeting.

Has anyone any comments to make upon what I have just said?

— Approved.

Meeting of the 14 May 1930 (morning).

— The Secretariat of the Section was the same as at the Meeting held on the 10 May.

Mr. Ghilain, *General Secretary.* — Our business is to complete the summaries on Question VI.

The Second Section has met and proposes to complete the summaries common to Questions V and VI, by the text already published in the *Daily Journal of the Session.*

Has anyone any objection to raise against these supplementary summaries?

— In the absence of any remarks, the summaries were taken as agreed.

The President. — The following therefore is the complete text of the summary relating to Question VI :

Summary.

« The Congress recommends to the « Railway Companies and Administra- « tions present :

« 1. To encourage efforts to create « new types of locomotives and to « improve the current Stephenson type

« of locomotive by facilitating in par- « ticular the initiative of locomotive « builders;

« 2. To develop further in particular « the use of extra-high steam pressures « and of the internal combustion loco- « motive;

« 3. To carry out methodically trials « of locomotives of new types and dif- « ferent designs built by various makers « and to publish the results of such « trials systematically and as made;

« 4. To co-operate with a view to the « erection of locomotive experimental « stations : the international collabora- « tion of such stations would facilitate « progress in scientific locomotive de- « sign;

« Among the recent improvements « which have taken place in steam loco- « motives of normal construction, spe- « cial attention should be given to :

« *a*) Increase in the temperature of « superheat, and

« *b*) The pre-heating of the feed « water.

« Taking into account the numerous « trials which have been carried out by « many of the Railway Companies, and « the experiences gained over many « years, this Congress is of the opinion « that :

« *a*) The temperature of superheat « can, in, pratice, be taken to 400° C. « (752° F.), special attention being « given to lubrication and the method of « steam distribution;

« *b*) That there are in service meth- « ods for pre-heating of water which are « giving satisfaction.

« The Congress recommends the « adoption of these two improvements « on account of the important economies « which can be realised from them. »

— This summary was approved by the General Meeting.

[621.335]

QUESTION VII.

ELECTRIC LOCOMOTIVES FOR MAIN LINE TRACTION.

a) *passenger locomotives;* b) *goods locomotives;* c) *locomotives for mountainous country. Multiple-unit traction.*

Preliminary documents.

1st Report (France and Colonies), by Messrs. DE BOYSSON and LEBOUCHER. (See *Bulletin*, September 1929, p. 1733 or separate issue No. 22.)

2nd Report (America), by Mr. J. V. B. DUER. (See *Bulletin*, July 1929, p. 887 or separate issue No. 9.)

3rd Report (British Empire, China and Japan), by Dr. K. ASAKURA and Dr. H. IMAIDZUMI. (See *Bulletin*, September 1929, p. 1681 or separate issue No. 21.)

4th Report (other countries, except Germany), by Mr. G. BIANCHI. (See *Bulletin*, December 1929, p. 2997 or separate issue No. 46).

5th Report (Germany), by Dr.-Ing. W. WECHMANN. (See *Bulletin*, April 1930, p. 1309 or separate issue No. 75.)

Special Reporter : Mr. G. BIANCHI. (See *Bulletin*, May 1930, p. 1410.)

DISCUSSION BY THE SECTION.

Meeting held on the 8 Mai 1930 (morning).

MR. WECHMANN IN THE CHAIR.

The President (in German). — We shall now deal with the question of electric locomotives for main line traction.

I shall ask **Mr. Bianchi**, *Special Reporter*, to read to us point by point the summary of his special report.

Mr. Bianchi (in French). — As desired by the President, I am going to read in succession the different points of the summary of my special report, and this will be followed by a discussion on the matter.

1. Although the introduction of electric locomotives already dates back some tens of years, electric locomotives still do not show, not even in their general design, the uniformity of design that steam locomotives presented within a few years of their first invention.

This being so, it appears necessary to form conclusions of a general character

and to limit the final observations and the discussion to arguments which can be considered as common to the different systems.

2. As regards the *most used types of drive*, the following remarks can be made :

A. — As regards *the system with motors having the nose spring supported*, the most usual with continuous current, if the speed is not to exceed about 90 km. (56 miles) per hour, a discussion on the following points would appear to be useful :

a) What are the maximum limits of power, weight of motor, and speed, with this system, which can be used in practice ?

b) What are the limits of power and axle weight for which gears with spring drive are considered preferable ?

c) What has been the experience of the different administrations as to the action on the rails and the wear of wheel flanges of locomotives with the motors, the nose of which is spring supported, and fitted or not fitted with leading trucks or bogies ?

B. — *The individual drive of the axles* by gearing and motors rigidly fastened to the main frames has resulted in quill drives or drives by gears projecting beyond the outside face of the driving wheels or in vertical motors driving through conical wheels and hollow shafts.

As regards quill drives, which are the most used, a discussion on the results given by the different types of springs or rods used to couple the hollow shaft to the wheels would be of value.

It would also be of interest to learn what is thought of the results obtained with the two other systems.

C. — On locomotives with low speed motors, articulated rod types of drive have recently been introduced and these theoretically have advantages over the older rigid triangular rods. It may be asked if these advantages are confirmed in practice.

The President (in German). — First of all, the motor having the nose spring supported is of special interest. According to most of the reports it is used for speeds up to 80 km. (50 miles) per hour.

Mr. Leboucher, *Reporter* (in French). — On the French railways, 90 % of the locomotives may be said to have their motors suspended by the nose, and a speed of 90 or even 95 km. (56 and 59 miles) per hour is regularly attained. On the Paris-Orleans trials have even been made with trains reaching speeds of 105 and 110 km. (65 and 68 miles) per hour with motors suspended by the nose.

French motors generally weigh between 4 and 5 tons.

I understand that in Germany, they have recently built some single-phase motors, with the nose spring supported, of about 500 H. P., and certainly weighing more than 5 or 6 tons. It would be interesting to know what speed these motors can attain.

The President (in German). —In addition to a large number of locomotives having the motor spring supported by the nose, for speeds of up to 65 km. (40.4 miles) per hour, the Reichsbahn have recently put into service two express locomotives equipped with motors of this type which run on the lines between Halle, Leipzig and Magdeburg.

Each A. C. motor weighs 4 800 kgr. (10 580 lb.). By using a motor casing of welded steel plate, it would be possible to reduce the weight to 4 500 kgr. (9 920 lb.) exclusive of the gears. The continuous power developed by a motor at its shaft is 525 kw. on the test bed and, as

an estimate, 550 kw. on the locomotive during running, for 1 600 r. p. m., corresponding to a speed of 112 km. (69.6 miles) per hour.

The non-spring supported weight on the driving axles is 5 1/4 tons, that is, about the same as for steam locomotives where in certain cases non-spring supported loads of up to 6 tons are found.

Mr. Bianchi (in French). — I think that it would be useful to ask the opinion of the Japanese reporters who have criticized in their report the motor with spring supported nose. It would also be interesting to have the opinion of the American delegates.

Mr. Onoe, Japanese Government Rys. (in German). — I can only refer you to the report by Messrs. Asakura and Imaidzumi who have made a special study of these questions, but who have been able to be present at this Session.

Mr. Bianchi (in French). — The possibility of using motors having the nose spring supported, for speeds of 110 to 120 km. (68 to 75 miles) per hour would constitute a considerable advance. In fact, this system is the simplest and the most practical.

The President (in German). — There are two principal types of drive, the Westinghouse drive and that which was first used by the engineer Buchli. It would be interesting to have some information on the comparative value of these two systems.

In Germany we have tried both of them and we have found that the same quantity of lubricating oil is required for the two systems, although the construction is quite different.

Mr. Bianchi (in French). — As regards gears with and without spring drive, we have tried both systems in Italy. The results were absolutely the same, so that the springs may be omitted, which is of considerable interest from the economical standpoint. However, this relates to locomotives having a weight per axle not exceeding 15 t. (14.7 Engl. tons). It would be interesting to know if it has been found necessary to provide gears with spring drive for greater weights per axle.

Perhaps Mr. Leboucher will be able to give us some information on this subject.

Mr. Leboucher (in French). — As remarked by Mr. Bianchi, it would be a great benefit to be able to dispense with the springs which cause maintenance troubles in service.

Let us see what are the parts which may suffer through the absence of springs. Passing from the rail to the frame, the weak parts are : 1. The part of the axle on which is fixed the gear wheel and which may fracture at the key way; 2. The teeth of the wheel and of the pinion, which may also either fracture or wear too quickly; 3. The motor shaft which may break owing to torsion; 4. Finally, the bearings of the motor may wear unequally owing to considerable stresses, especially if they are unsymmetrical.

The danger of the axle breaking may be avoided by fixing the gear on the wheel centre. The stresses may be made symmetrical by providing a gear on each side, and then the axle is no longer subjected to torsion. There is nothing to fear for the gear teeth when so mounted, especially when double gearing is used.

We can state that with our locomotives numbering over 100, and which have so

far run about 30 000 000 km. (18 600 000 miles) we have never had a broken axle or tooth unless the steel was defective, and the locomotive which has run the longest distance exceeded 800 000 km. (500 000 miles) almost without tooth wear.

It follows that when gears are fitted symmetrically with motors spring supported by the nose, there is absolutely nothing to fear up to 19 t. (18.7 Engl. tons) per axle, and that suppression of the springs is undoubtedly an advance from the point of view of upkeep and cost price.

Mr. Bianchi (in French). — I absolutely agree with Mr. Leboucher.

The President (in German). — The two express locomotives, with motors having the nose spring supported, of the Reichsbahn, have a weight of 20 t. (19.7 Engl. tons) per driving axle. The large gear wheels have springs. When we purchased these locomotives there was no experience to show how this transmission behaves at high speeds. While one of the locomotives is provided with the usual form of suspension by the nose, the other has been provided, on the side of the jaw bearings, with a sort of rudimentary suspension in the form of a transverse steel bar. The amount it can give is about 2 mm. (5/64 inch).

Mr. Weiss, *Vice-President* (in German). — The Swiss Federal Railways do not possess any locomotives equipped with motors having the nose spring supported. I am therefore only able to express so to speak a theoretical opinion. I think that one point has not been taken into account in speaking of the non-spring supported weight of the motors and in stating in this connection that this weight is no more unfavourable than on certain steam locomotives and principally those with 4 cylinders, the pistons of which act on only one axle. Now, the difference between steam locomotives and electric locomotives consists in the fact that, during a vertical movement, which may be caused by irregularities in the track, the motor is accelerated or retarded, which makes itself felt in shocks on the transmission. We have found this to be the case on our rail motor coaches. I therefore think that the motor with the nose spring supported can only be used for high speeds if the track is in perfect condition, but I doubt whether when the track is not in such good condition, this system will give good results in the long run. It would be interesting to know what results have been obtained in Spain where, if I remember rightly, axles have broken on locomotives of relatively recent construction.

Mr. Eulate, *Section Secretary* (in French). — We have had broken axles on goods locomotives of the six driving axles type, equipped with motors of the spring supported nose type. The weight allowed by the North of Spain Railway Company is 17 t. (16.7 Engl. tons) per axle. Actually, owing to the load per axle being increased to 18 t. (17.7 (Engl. tons) the locomotives have been rebuilt with an additional carrying axle with a view to reducing this axle load. We have had many of the first and sixth axles broken. The quality of the steel of the axles was tested and it left nothing to be desired.

As these fractures occurred near the wheel, they must be attributed to torsional stresses.

The President (in German). — Has anyone any communication to make on the subject of other systems of indivi-

dual drive, as for example, the Westinghouse or the Buchli or other new systems which are also mentioned in the reports.

— As no one desired to speak, the President invited Mr. Bianchi to read out point 3 :

There is still no standard arrangement of *trucks and bodies* except for the types formed of several bogies all the axles of which are driven with motors of the spring supported nose type which types are very usual among continuous current locomotives for passenger and goods working at speeds not exceeding 90 km. (56 miles) per hour.

On this subject a discussion on the following points would be interesting :

a) Should the bogies be coupled directly together, the draw and buffing gear be fastened to the bogies themselves, or should the bogies not be coupled and the draw and buffing gear be attached to the body ?

It would also be useful if the different types of springing used for the bodies were discussed :

a) Locomotives with driving and carrying axles with a single main frame often have driving axles which can move laterally up to as much as 25 mm. (1 inch).

On some locomotives all driving axles can move laterally whilst on others only one or two axles can move in this way and to the minimum permissible extent. It would be interesting to know which system gives the best results.

The President (in German). — The discussion is open on this point No. 3.

Mr. Leboucher (in French). — In France, the Paris-Orleans and the Midi Companies have used two different designs which are equally good. The two railways are very satisfied with them but they are distinctly different in principle. On the Paris-Orleans, the locomotive has its two bogies absolutely independent, and the body carries the draw and buffing gear. On the Midi, on the contrary, the two bogies are coupled together and carry the draw and buffing gear. The reason for adopting this arrangement is as follows : For very high speeds, it is necessary to prevent hunting movements of the body. In the case of a B + B locomotive, the pivots are situated at 1/4 and 3/4 of the length of the body and, when the two bogies start an oscillatory movement relatively to one another, the end of the body amplifies and doubles this movement so that, at certain speeds, at a given moment the bogies move one to the right and the other to the left. To avoid this defect, the Midi Company has provided a coupling which brakes the relative displacements of one bogie with respect to the other, and speeds of 100 km. (62 miles) per hour may easily be attained without hunting.

It would be interesting to know if anything similar has been adopted on other railways abroad and if any trouble has been experienced with either of the designs.

Mr. Bianchi (in French) — In Italy we have some B + B + B locomotives. The three bogies have been coupled together by means of spherical couplings which prevent all relative movement except rotation. We have obtained very good results.

We have tried however to provide some slight relative movement between one bogie and the other, but this arrangement immediately gave trouble. It was observed that the bogies should be coupled together and the relative movements should be reduced to one of rotation without longitudinal or lateral movement.

The President (in German). — As regards high power locomotives and particularly goods locomotives, it has not been possible so far to abandon the subdivided type of construction. However, the results obtained with these locomotives in two or three parts are not entirely satisfactory. The effect of the short frame is to make the locomotives unstable when running and to set up considerable oscillation. In case of derailment, they are difficult to rerail. The numerous pipe and hose pipe connections are troublesome and the repairs are heavy. Inspection in the sheds takes 25 % longer than for single unit locomotives, so that we now prefer the latter construction.

Mr. Bals, Rumanian State Rys. (in French). — Although on the Rumanian Railways there is no electric traction, I understand that certain railways are using or are still experimenting with a system for reducing the hunting of very high speed locomotives mounted on independent bogies.

The principle appears to be that hunting becomes very great at high speeds when the two bogies have symmetrical arrangements of the axles. At certain speeds resonance phenomena are produced in some way in the movements of the two bogies.

Certain administrations are employing unsymmetrical axle arrangements, for example, 1 B 1 + B 1 instead of 1 B + B 1.

It would be interesting to know if good results have been obtained in this way.

Mr. Weiss (in German). — The Swiss Federal Railways possess a type of locomotive having an axle arrangement denoted by 1 B 1 + B 1. The reason for this unsymmetrical arrangement is simply not to exceed the permissible loads on the axles. By adding a carrying axle, the load on the driving axles has been reduced to 18.5 t. (18.2 Engl. tons), a necessary reduction in view of the additional stresses set up with the Westinghouse driving gear. These stresses are set up in the event of a non-concentric position of the driving axle and the hollow shaft occurring. The running of the locomotives was generally satisfactory from the point of view of lateral movement. On the other hand, the 1 B 1 + B 1 locomotive shows considerable wear of the leading flanges of the inner driving wheels. By subsequently mounting a transverse coupling between the frames, wear has been very considerably lessened owing to the conjugate guiding of the rear frame.

On another vehicle, the troublesome hunting movement which started at speeds of 60 km. (37 miles) per hour and over was cured by inserting between the bogie and the frame friction plates which may be tightened as desired.

The President (in German). — Has anyone any further communication to make ?

Mr. Cortez Leigh, London Midland & Scottish Ry. — I would very much like some further information on one or two points. The gear described in figure 4 of Mr. Bianchi's report, using radial plate springs instead of helical springs is quite a novel one, and it would be very interesting to have some further information as to the results given by this drive in service.

I notice that some of the locomotive drives shewn in the diagrams appear to be extremely complicated in their rod drive arrangements. For example, in the case of two of the diagrams, figures 46 and 47, there are some 16 pin joints per

side. It would be thought that the cost of maintaining these drives must be extremely high and one would think that the non-spring borne weight, rotating as it does and giving rise to both vertical and horizontal stresses, must be detrimental both to locomotive and track.

If Mr. Bianchi can give us some further information as to what he considers the best wheel arrangement among those illustrated it will be very useful, coming from an Engineer of his wide experience in this class of work. The wheel arrangements illustrated are practically all symmetrical, and in Great Britain it is not considered as established that a symmetrical engine is a good running engine.

Electric locomotives being intended to run in either direction present a different problem to steam locomotives, which, of course, are mainly designed for full speed travel in one direction only.

It may prove that a better « both directional » electric locomotive can be built with a non-symmetrical wheel arrangement than with a symmetrical, even though the former may travel slightly better in one direction than in the other.

I think this is pretty well the case with the extensive class of Swiss Railway high-speed passenger engines both of the B. B. C. and Oerlikon types which have a bogie at one end and a Bissel truck at the other, and which according to my experience travel very satisfactorily both ways, though it is understood that if anything, they are somewhat better with the bogie leading.

The President (in German). — As the point raised by Mr. Cortez Leigh is not at present under discussion, Mr. Bianchi and Mr. Weiss have stated their willingness to give him personally and directly the information he desires.

Is there anyone who would like to speak further on the general construction of the locomotives ?

Mr. Bianchi (in French). — Another question is that of the lateral displacement which must be given to the axles in the case of non-articulated locomotives.

In Italy we have attempted to give a certain lateral displacement to all the driving axles, but on straight lines hunting was set up. I should like to have the opinions of the other Administrations on this subject.

The President (in German). — Can anyone reply to Mr. Bianchi's question ?

— No reply.

Mr. Japiot, Paris, Lyons & Mediterranean Ry. (in French). — I should like to give some additional information in support of what Mr. Weiss has said regarding the advantages obtained by causing one bogie to be guided by the other on locomotives provided with several bogies.

Our fast locomotives are provided with bogies coupled together by means of ball joints and we have found that the leading flanges of the axles on each side of the articulation did not wear any more rapidly than those of the other axles, and this proves the effectiveness of guiding one bogie by another. The remark which Mr. Weiss has made on the Swiss locomotives is thus entirely confirmed by ours.

— The discussion was then suspended until 11.40 a. m. for the reading of the final summaries relating to Question V.

Resumption of the discussion.

The President (in German).— We now come to point 4 of the summary which Mr. Bianchi will kindly read to us.

Generally speaking the *axle load* allowed for electric locomotives is higher than that allowed on the same railway for steam locomotives. It is also known that certains types of electric locomotive, in particular those with individual gear drive and with the motors on the frames, although the weight per axle is higher than on other types, have shown that they do very little harm to the track and run very steadily at even the highest speeds.

It would be interesting to hear a review of the observations made on the action on the track and the steadiness in running of the different types of locomotives having, for a given axle weight, a very low centre of gravity or a large proportion of unsprung weight.

Mr. Leboucher (in French). — Everyone admits that electric locomotives are less trying to the track than steam locomotives, in which the rotating masses and the reciprocating masses cannot be balanced simultaneously. The result of this is that the axis of the axle is not the principal axis of inertia, and that the action of the unbalanced masses stresses the track at each revolution, so that, at very high speeds it may be said that an axle loaded to 15 tons, of a steam locomotive, stresses the track more than an electric locomotive axle loaded to 20 tons because the latter is perfectly symmetrical. It is therefore quite natural that electric locomotives should stress the track less than steam locomotives.

There are, however, some electric locomotives which have a very bad reputation with regard to their action on the track. This is in particular the case with the gearless type of locomotive. The almost general opinion is that the gearless locomotive punishes the track owing to the very low position of the centre of gravity of the axles.

However, it may be said that the centre of gravity of the axle of the gearless locomotive is not much lower than that of the axle of a B + B locomotive, of the spring supported nose type. I think that the axle of the gearless locomotive punishes the track so much because it is so rigid. The wheels are small, the axle is large, and above all the axle carries the armature keyed to the shaft, so that it is practically an axle which is indeformable under lateral stresses.

I consider this to be the principal reason for the bad reputation of the gearless locomotive. I should be very glad to know the opinion of the administrations who possess locomotives of this type, on this subject.

My opinion is therefore that the gearless locomotive punishes the track not because its centre of gravity is low but because the axle is too rigid.

The President (in German). — May I ask what is the maximum speed for this locomotive ?

Mr. Leboucher (in French). — I understand that on the Paris-Orleans, where there is one gearless locomotive, the designed speed was 120 km. (75 miles) per hour, but above 100 km. (62 miles) per hour it rode so badly that it had to be completely rebuilt.

This locomotive was originally built in three sections. The Paris-Orleans Railway modified this arrangement by providing a single body with two trucks each having three driving axles, and two bogies.

Mr. Bianchi (in French). — And the draw gear carried by the body instead of the bogie ?

Mr. Leboucher (in French). — The draw gear on the body.

Mr. Bianchi (in French). — I much regret that our American colleagues have been unable to be present at this meeting to give us some information regarding the tests of the General Electric Company, which tests appear to have been favourable to the gearless locomotive.

However, the speeds in America do not appear to have exceeded 70 km. (43.5 miles) per hour, whereas on the Paris-Orleans, the speed exceeded 100 km. (62 miles) per hour. I do not think that any more gearless locomotives will be built anywhere.

The President (in German). — I should like to point out that the gearless type of locomotive cannot be used with single-phase and three-phase current.

We shall now take to point 5 : *Coefficients of adhesion.*

Mr. Bianchi :

5. Coefficients of adhesion. — Data on the relative adhesive weight and tractive effort should be given to bring out the minimum coefficients of adhesion required for the different types of locomotives to be able to develop the effort corresponding to the hourly, the continuous and the maximum rating for a short period. The discussion could bring out the circumstances in which the coefficients of adhesion, in practical working, fall with certain locomotives to values appreciably lower than usual, while other types of locomotive, on the contrary, under the same working conditions, have higher coefficients.

As regards lubrication methods, the results obtained with the different types of lubrication for the gears are very interesting.

Mr. Bals (in French). — The Rumanian State Railways are not yet using electric traction but the question interests them very much, as the electrification of one of our mountain lines is under consideration at the present time. That is why I should like to ask a question regarding the tractive effort.

The data given in the reports show that the maximum tractive efforts of several types of locomotives in different countries are very high, being 30, 34, and even 36 t. (29.5, 33.5 and 35.4 Engl. tons).

Considering that the rolling stock is the same as that used with steam traction and that the strength of the draw gear is at the present moment, in Europe, relatively low (the strengthened draw gear as prescribed by the International Union having a breaking strength of 65 t. (64 Engl. tons), I should like to know if the special features of electric traction are such as to permit, without fear of breakage, of the tractive effort being increased to such high values and if experience has shown that special precautions have to be taken to avoid breaking the couplings at the moment when these maximum efforts are developed ?

The President (in German). — Is there anybody who is able to reply to the question asked by Mr. Bals ?

Mr. Bianchi (in French). — Mr. Bals has made a very just remark, but his question may be answered by saying that electric traction is still in its first stages. As was mentioned just now, the pull on the draw bar hook is laid down by an

international decision, but it is possible that in the future a further increase will be considered. If the tractive efforts allowed in America were then reached, it would be necessary to alter all the locomotives. For this reason the new Italian locomotives have been designed for tractive efforts which they never give at the present time in practice, but which may be required in the future.

Mr. Bals (in French). — I am grateful to Mr. Bianchi for his explanations which satisfy my enquiry.

At the present time, with the current type of coaches which have relatively weak couplings, is it necessary to provide some system to prevent the driver from developing by mistake too great a tractive effort ?

Mr. Bianchi (in French). — Formerly we had on our locomotives a device to limit the tractive effort to the prescribed values, a sort of wattmeter which prevented the driver from making a mistake, but we have been able to dispense with it, as we found in practice that the driver never overlooked this point.

Mr. Leboucher (in French). — On the subject of coefficients of adhesion, there is one piece of information which would be valuable to know and which has not yet been thoroughly examined and that is the question of the variation of the coefficient of adhesion with the speed. This question has been studied fairly recently I think in Switzerland, but it has not been possible to carry it as far as it might have been.

The question of adhesion becomes of greater importance with electricity than with steam for this reason. In steam locomotives, there are generally several coupled axles, so that a pair of wheels cannot slip without involving the others, and, practically, slipping hardly ever takes place with steam locomotives except where the rails are very greasy, for example on starting, but when running freely it is quite rare for a steam locomotive to slip. With electric locomotives, on the contrary, slipping is extremely frequent, especially when the locomotives have individual drives. It may be caused by several factors. In particular, for the B + B's, the locomotives with two motor bogies, traction causes the bogie to pivot by relieving one axle of load and loading the other. The higher the pivot, the more easily does this take place.

Theoretically, if no displacement is to take place, the pivot should be placed in the plane of the rails, a condition which it is impossible to realise in practice.

In very powerful locomotives, having two coupled bogies, the occurrence takes place when the locomotive, for example, is beginning to run up a gradient. The rigid coupling loads one of the axles, the rear axle, and relieves the front axle of load, so that one of the driving axles begins to slip, and the driver has to bring it back to zero, because when an axle slips it exceeds the racing speed limit, and if it was allowed to slip, there would be a risk of bursting the armature.

It would by very desirable for the Administrations to study the law of the variation of the coefficient of adhesion with the speed.

For electric locomotives, the coefficients of adhesion chosen vary between 0.20 to 0.125. If a coefficient of adhesion greater than 0.125 is chosen for a locomotive, it is almost certain that slipping will take place when starting. Obviously, this value of the coefficient means a fairly high locomotive weight. It would be interesting to have some precise figures of coefficients of adhesion.

Mr. Weiss (in German). — I regret that I cannot give reliable information on the subject of the coefficients of friction because the tests have not been made by the railway administration but by an engineer of the Sécheron firm. They have been published in the technical press. As regards adhesion, it is necessary to take into account the different methods of drive and control and the different kinds of current. Originally, we were of the opinion that locomotives having coupling rod drive were superior to those having individual drive. We have found however, that the locomotive with the Westinghouse transmission for example is no more liable to start hunting than one having coupling rod drive. The motors must be connected in parallel and the controller have numerous running notches.

The President (in German). — The Reichsbahn uses in Silesia two kinds of heavy goods locomotives with 6 driving axles. One is of the C + C type, having coupling rod drive, and the other, of the 1 Co + Co 1 type, has individual axle drive. There was some fear that with the latter, it would not be possible to make full use of the adhesive weight. It has been found, however, that these fears were not justified. It is true, as Mr. Weiss has remarked, that the motors must be connected in parallel.

Mr. Bianchi (in French). — The last remark is very true, but it should be pointed out that there are systems in which the motors are always connected in series, for example, the 3 000-volt D. C. system.

On the Italian State Railways, it has been found that the Bo + Bo + Bo locomotives have a greater tendency to slip than the other types of locomotives, this being due to the connection in series of the motors of the spring supported nose type.

I think that locomotives with motors having the nose spring supported and always connected in series may be regarded as having in general smaller coefficients of adhesion than the other types.

Finally, it may be remarked that locomotives with coupling rod drive have less tendency to slip than steam locomotives.

The President (in German). — We have now finished the discussion of the first main division of our subject, that is, the mechanical part. There is still the electrical part to be discussed.

— The Section agreed to postpone the discussion of the remainder of Question VII to Monday, 12 May, and the meeting closed.

Meeting of the 12 Mai 1930.

PRESIDENT : Mr. WECHMANN

The President (in German). — We shall now resume the discussion on Question VII and take the second division : *The electrical part* of the electric locomotive.

Mr. Bianchi, *Special reporter*, read paragraphs 6 of his summary as follows:

As regards operating the pantographs two ideas are followed :

a) The lift is by compressed air

which, by means of a piston, puts into tension the spring holding the pantograph up to the overhead line. The pantograph is lowered by gravity;

b) The lift is by springs always in tension which give the required pressure against the overhead line. The lowering is by compressed air which counteracts the action of the said springs.

It would appear of interest to know the ideas of the administrations using the two systems mentioned, both as regards speed and ease of operation and as regards the safety of the staff.

As regards the pressure of the shoe on the contact line, a discussion on the various reasons the different railways had when fixing the values considered optimum, would be very interesting.

Mr. Eulate (in French). — In Spain we have two systems :

1. Lifting the pantographs by springs.
2. Lowering the pantographs by springs.

The first system is much more rapid, but a little more dangerous because if the locking device does not function properly, the pantograph becomes unhooked which may cause accidents.

However, both systems work very well if the locking device is attended to properly. The spring actuated system is more rapid in operation than the compressed air system.

Mr. Leboucher (in French). — The remark made by Mr. Eulate is quite correct.

I think, however, it would be as well to give the reasons which have led some railways to prefer the spring operated lift.

With the compressed air lift, the lowering of the pantograph is only obtained by releasing the air, whence a first delay owing to the escape of the air. The second delay is due to the fact that the only force available for lowering the pantograph is gravity which acts fully on the bow, partly on the lateral bars, and practically not at all on the rotating parts.

As regards lowering the pantograph, it may be assumed that it is two or three times as slow as that of a free body falling by itself. In many cases, the driver of the locomotive, noticing for example a damaged overline, has not time to lower his pantograph and 200 or 300 metres of line is torn down.

If, on the contrary, lowering is effected by compressed air, a practically unlimited force is available because pistons may be provided of such dimensions as to cause the lowering of the pantograph to exceed in speed that of a free body under the action of gravity.

As to the question of safety, the remark made by Mr. Eulate is perfectly justified. We have, however, two locks; a compressed air lock and a hand operated lock. During the day, the compressed air lock only is used, and in the evening, when the locomotive is put into the shed, the hand lock is closed and the compressed air lock is opened, so that on resumption of the service, the driver has only to operate the hand lock to be able to use the compressed air lock during the day.

One thing is certain, and that is that on a stock of 150 locomotives, we have never had to regret a single accident.

Mr. Cortez Leigh. — This question is indeed a very important one, and I think that if there is machinery for providing a method for the further testing of the principles of a spring-raised pantograph against a pressure-raised pantograph it is very desirable that it should be made use of.

I personally favour the pressure-raised pantograph, because once the air pressure fails, the pantograph lowers automatically, and failure is, therefore, on the safety side. In Great Britain, the same compressor which is used for the brakes provides the pressure for the pantograph through a reducing valve and auxiliary reservoir. There is no difficulty in getting pressure for the pantograph at any time if a hand pump is provided to give the initial pressure when bringing into service. I prefer the pressure raised system to the spring raised system. It is a matter which requires further research, and some unanimous decision should be arrived at on the matter.

Mr. Cuttica, Italian State Rys. (in French). — I think that it would be of interest to know the time required in practice for the two systems of raising and lowering the pantographs.

Mr. van Lessen, Netherlands Rys. (in German). — The Netherlands State Railways have paid considerable attention to this question. It is true that we do not employ locomotives, but fast standard gauge rail motor coaches. As regards the question we are discussing however, this does not make any difference.

We decided to use the pressure raised pantograph. No damage to the line has been caused by the fact that the pantographs could not be lowered with sufficient rapidity. The driver can be warned that a line is damaged, in time for him to lower the pantograph. It hardly seems necessary, therefore, to impose the condition that the lowering speed should be very high.

The President (in German). — Does anyone else wish to speak on this point ?

Mr. Cardon, Paris-Orleans Ry. (in French). — Mr. Leboucher has said that there have never been any fatal accidents with the spring raised pantographs of the Midi Railway.

On the Paris-Orleans Railway we consider that safety is ensured in an absolutely reliable manner — and in particular from the point of view under consideration — by the compressed air lift which has been adopted. Moreover, the pantographs are prevented from lifting by suitable catches if the ladder giving access to the roof is unfolded. If we have really had a serious accident, it has been due to a constructional defect in the catches permitting the pantograph to be lifted by the hand pump. This defect has been remedied.

As regards the rapidity of lowering the pantographs, we have found that there was some difficulty in lowering one of the types employed when running at speeds of 90 km. (56 miles) per hour and over. At the same time that we had to strengthen the collector shoes, found to be too weak, which increased their weight somewhat, we altered the adjustment of the springs. In this way, we have been able to lower this type of pantograph, as all the others, in 8 to 10 seconds at 120 km. (75 miles) per hour.

If we examine the importance of quick lowering from the practical standpoint, we find that the necessity for lowering the pantographs is not always due to unexpected damage to the contact line being discovered by the driver at the moment he arrives at the damaged portion. Moreover, at night it is practically impossible for it to be discovered. On the whole, this case is quite uncommon. Actually, to ensure reliability in operation and for this purpose to reduce to a minimum the consequences of damage to the contact line, it is above all necessary, as Mr. van

Lessen has said, to prevent the trains which have not already come to the damaged region from increasing the damage when they get there. To fulfil this indispensable condition does not merely involve the speed of lowering of the pantographs. The time taken for lowering the pantographs is only one of the factors which are taken into consideration in deciding the warning measures that are taken (issue of pantograph lowering notices or erecting special signals).

The few accidents which have occurred in such cases on the Orleans Railway have been caused either through mistakes on the part of the men or through poorly designed pantographs.

After taking into account these considerations and above all the absolute reliability provided over the whole installation and in all cases by lifting the pantographs by compressed air, the Orleans Company adopted this method.

Mr. Weiss (in German). — The Swiss Federal Railways employ exclusively compressed air lift pantographs. We have overcome the inconvenience due to the slow rate of lowering by providing each cylinder with a release valve operated pneumatically or electrically. It has been possible to reduce the time taken to lower to 5 or 6 seconds. We have also tried automatic lowering devices but we found that they were not sufficiently reliable in operation.

Mr. André, *Vice-president* (in French). — I should like to ask Mr. Cardon a question about pantographs. Have not the Paris-Orleans Railway had to redesign the details of the pantograph in order to overcome the resistance opposed to lowering at high speeds ?

Mr. Cardon (in French). — As a matter of fact, we had thought of modifying the design so as to take advantage of the action of the air to combat the tendency the upper part of the pantographs mentioned has to glide somewhat after the fashion of an aeroplane, but we have abandoned this idea. The alterations made and which I mentioned just now have, in fact, produced the desired improvement.

I might add in this connection that the rapid lowering of a pantograph lifted by air is easy to realise if absolutely needed. We have carried out experiments on this point.

At that time we had in mind two possibilities which sometimes arise : the locomotive runs on to a portion of the track where the damaged contact line has been lifted up, without it having been possible to warn the driver, or the locomotive, owing to wrong switching, runs onto a track without any contact line. In these cases, we wanted to obtain an immediate lowering of the pantograph caused by its own unfolding beyond a certain fixed height. We obtained this immediate descent perfectly, but we have not put into general use the experimental device, which was very rough in action.

Finally, I think it will suffice to point out that on the Orleans Railway we total monthly more than a million kilometres for our pantographs, from which we way conclude that this system has proved itself amply satisfactory in all respects.

The President (in German). — In view of the late hour, I should like to request the speakers to be as brief as possible.

Mr. Cuttica (in French). — On the locomotives of the Italian State Railways, the pantograph is raised by compressed

air. The time taken for lowering is 7 to 10 seconds.

Mr. Leboucher (in French). — Mr. André referred just now to a modification which should have been made by the Paris-Orleans Railway, but actually it was the Midi Company which did this. We first of all calculated our pantographs so that the action of the wind at very high speeds would be balanced and the bows would remain horizontal. The calculation was wrong, and the plane of the bow, instead of remaining horizontal, was lifted forward under the action of the wind. It follows that the vertical component of the wind tended to lift the pantographs instead of to lower it. We added an aileron to the lower part of the bow so as to cause the latter to swing towards the front and thus produce rapid lowering of the pantograph.

As regards the different objections to raising by air or raising by springs, it is found that in order to obtain a speed of lowering of about 5 seconds it is necessary to fit additional valves on the cylinders or to increase the weight of the bow. Such a complication is, however, in my opinion, a very grave drawback. In designing a pantograph, the greatest care is given to get a bow as light as possible, because after all the only available force is the pressure of the pantograph on the line, and the whole of the dead weight of the pantograph has to be overcome. It is the ratio of the force to the dead weight which in principle shows the good design of the pantograph, that is to say, its faculty of sticking to the line, its faculty of not increasing the pressure of the pantograph when the line is lowered and of preventing it from coming away when the line rises again.

In short, I consider that the pantograph should not be made heavy with a view to ensuring its rapid descent.

Mr. Bianchi (in French). — I should like to add a few words on an occurrence quite recently observed in Italy on locomotives having two pantographs. The leading pantograph on the locomotive, at high speeds, had a tendency to lift while the trailing pantograph had a tendency to drop. The aeroplane effect is only exhibited therefore by the front pantograph and not by that fitted at the trailing end of the locomotive.

This may be explained on realising that the direction of the wind is from below upwards at the front of the locomotive whilst at the back the air displaced by the locomotive itself tends to lower the pantograph. For a static pressure of 10 kgr. (22 lb.), an increase of 4 kgr. (8.8 lb.) has been found at the front pantograph, and a reduction of 3 kgr. (6.6 lb.) at the back pantograph.

The President (in German). — The Reichsbahn has standardised the pantograph and its control. As detailed descriptions have been published I shall not describe the arrangement here. I should merely like to remark that the Reichsbahn also uses compressed air for lifting the pantograph. Difficulties due to the principle of the design have not arisen.

We shall now proceed to point 7 of the summaries.

Mr. Bianchi :

7. As regards *protection against overvoltage* it may be asked what are under present conditions the conclusions as regards the different arrangements considered indispensable for continuous current locomotives.

— As no one desired to speak on the

subject of point 7, the President asked for point 8 to be read.

Mr. Bianchi :

8. As regards *circuit breakers* required to open *automatically* by relays when the current becomes excessive or when the voltage exceeds a minimum or maximum value, two schools are followed :

a) Circuit breakers which cut off the current independently of the abnormal value of the current density or of the voltage and of the working of the sub-stations and feeders.

A discussion on the circuit breakers of alternating current locomotives of this class and on the different types and arrangements used to avoid explosions when oil is used, and a discussion on the results given by air breakers recently introduced, would be valuable.

As regards rapid and extra-rapid circuit breakers used on continuous current locomotives it is interesting to have confirmation that these breakers are the most suitable for protecting the gear against short circuits, and that the excess tension on suddenly breaking the current can be eliminated by suitable resistances.

b) Circuit breakers which in the event of a short circuit only open after certain others through the action of special relays.

In the case of alternating current locomotives the action of the relays is such that the locomotive circuit breaker in the event of a violent short circuit only opens after the nearest section breakers of the contact line.

For continuous current locomotives the relays only allow the current to be cut off after the intensity of the short-circuit current has been reduced by the insertion of starting resistances in the circuit.

As the two systems of breakers *a*) and *b*) are often used on the locomotives of an individual railway, it may be asked which is the better.

The President (in German). — I should like to ask the following questions on this subject :

Have there often been explosions of circuit breakers and what have been the consequences ? What steps may be taken to avoid them ?

On the lines of the Reichsbahn, serious incidents due to the main circuit breakers of the locomotives have fortunately not occurred. For many reasons, the presence of oil on the locomotive is not very desirable and the surest means of preventing an explosion in an oil circuit breaker consists in replacing the oil circuit breaker by a an oil-less circuit breaker. Experiments in this direction are now being made; on this point I would refer to my report (p. 1334 of the *Bulletin* for April 1930). I hope that next year the Reichsbahn will be in a position to test fully an oil-less circuit breaker.

Mr. Bianchi (in French). — On the subject of oil circuit breakers, circuit breakers containing a small quantity of oil have been used in Italy. They gave considerable trouble, especially when the level of the oil dropped, that is, when the arc was struck in a mixture of air and gas.

To remedy this, circuit breakers of greater capacity were adopted, in which the current was broken at the lowest level of the circuit breaker. This circuit breaker was even provided with pipes for the escape of the explosive mixtures of air and gas. The results obtained were very satisfactory. If the level of the oil is not very high, explosions are still possible even with this system, but in this respect, the experience with a stock of 223 loco-

motives for more than two years has been very good.

Mr. Cortez Leigh. — I wish to ask whether it would be possible to know if the oil in the circuit breakers referred to was defective in any way or was it the design of the circuit breaker which was at fault. I should also like particulars of the maintenance costs of the circuit breakers without oil; are they high or low as compared with oil circuit breakers ? By careful attention to the filtering of oil, failures have been in my experience, considerably reduced.

The President (in German). — Explosions in oil circuit breakers have undoubtedly occurred chiefly when the circuit breaker was preceded by a resistance and when the control mechanism refused to act. I am unable to furnish information regarding the maintenance costs of circuit breakers without oil, because the latter have not yet been in service.

The other question *b*) relating to this point consists in knowing if in the event of a short circuit, the circuit breaker of the locomotive must always break the circuit or if it is the circuit breaker of the sub-station. Which arrangement is recommended for alternating current ?

Mr. Bianchi (in French). — I asked this question for the following reasons :

Several reports mention that, to deal with a very heavy short circuit on the locomotive, devices have been fitted to prevent the circuit breakers of the locomotive itself opening, that is to say, the break does not take place on the locomotive, but at the sub-stations. I believe that this system has been adopted on the Swedish and Swiss railways.

This applies to alternating current locomotives; continuous current locomotives are not in question.

Mr. Weiss (in German). — The Swiss Federal Railways on all their electric motor stock employ a standardised circuit breaker having a capacity of 100 000 kva. This apparatus, constructed by Brown Boveri & Co. of Baden, is checked by means of tests carried out on a fixed stationary plant. The capacity I have just mentioned is 39 times that of the locomotive but it is not sufficient to damp a violent short circuit near the sub-station. That is why we are employing blocking relays, the effect of which in the event of a very powerful short circuit, is to make the sub-station circuit breaker cut off the current and stop the supply to the corresponding section of the line. After the voltage has returned to zero a no-voltage relay actuates the circuit breaker of the locomotive. This arrangement has proved satisfactory.

Mr. Öfverholm, Swedish State Rys. (in German). — In Sweden, we are employing oil circuit breakers which open when the strength of the short circuit current is 150 to 200 amperes. If the current exceeds 200 amperes, instead of the circuit breaker of the locomotive that of the sub-station opens. The circuit breaker of the locomotive has a no-current release. When, after the circuit breaker of the sub-station has opened, the current drops to zero, the circuit breaker of the locomotive is released.

Mr. van Lessen (in German). — In Switzerland, is the oil circuit breaker alone standardised, or is the blocking relay also standardised ?

Mr. Weiss (in German). — The blocking relay is already or is being fitted to all vehicles. It is therefore no longer on trial.

The President (in German). — So far, alternating current only has been discussed. It would be interesting to discuss the case of continuous current.

Mr. Bianchi (in French). — As regards the Italian continuous current locomotives, we have two systems : first the extra rapid system which interrupts the current independently of all the other circuit breakers of the locomotive and sub-stations, and secondly, on other locomotives the circuit breaker constituted by ordinary contactors which only open after all the starting resistances of the locomotive have been cut out of the line. It has been found that the extra rapid circuit breaker works very well, but I think it may cause overvoltages on the contact line, because when a very high current is interrupted, there is always a sudden rise in voltage on the line, which is capable of causing trouble.

I should like to have the opinion of Mr. Leboucher and Mr. Eulate, as well as that of other delegates who have high voltage continuous current locomotives.

Mr. Eulate (in French). — Our circuit breakers have always worked well and we have not had any trouble.

Mr. Bianchi (in French). — What system do you prefer ?

Mr. Eulate (in French). — I think the extra rapid system of circuit breakers is very good, but their maintenance is expensive.

Mr. Leboucher (in French). — The breaking of the continuous current is precisely the great difficulty and perhaps the only one which is met with in continuous current operation.

This is due to the fact that continuous current never passes through zero like alternating current, and the rapidity with which the current increases may attain 2 000 000 amperes per second. If the current is broken in a thousandth of a second, there may be 20 000 amperes. The breaking of 20 000 amperes is extremely difficult and corresponds to the line being struck by lighting. It produces a drop in voltage and afterwards an overvoltage which may attain several thousands of volts. It is therefore necessary to break the current before it increases, before it has attained a value which is difficult to break.

It is in this spirit that we have all sought to obtain circuit breakers which are, I shall not say ultra rapid, but « extra ultra rapid ». We have some which work very well, but we are looking for something better and at the present moment we have under test what we call a current strength limiter which breaks the current in a thousandth of a second. We have begun some extremely interesting experiments which are still in course of progress and according to which the current is broken before it attains its normal conditions.

In short, the principle of the circuit breaker which we have tested is to break the current in two steps : first step a resistance is put in at a very high speed, for example, in a thousandth of a second, and the current being reduced, it is broken. With the current limiter, we have been able to break the current at a strength lower than that given by the resistances.

I should like to draw your attention to these appliances, about ten of which are still under test. So far, the results have been very good.

Mr. van Lessen (in German). — The difficulties are due not so much to the

heavy current as to the high voltage, because if a short circuit is produced in the motor, the effect of the considerable inductance is that the current increases very slowly, while the voltage attains a high value. The break must thus take place with a weak current and at a high voltage.

Mr. Bianchi (in French). — I think the observations which have been made by Mr. Leboucher concerning the very satisfactory working of a high speed circuit breaker are due to the fact that this circuit breaker, if I have understood rightly, opens as a function of the derivative of the current with regard to the time, unlike the American circuit breaker, the opening of which is a function of the current.

The observations which I believe I have made regarding the troubles arising from the breaking of the current by an extra rapid circuit breaker do not apply to the circuit breaker discussed by Mr. Leboucher, because it opens at the commencement of the current increase and not when the current has already attained a certain value.

Mr. Leboucher (in French). — That is so.

Mr. Bianchi (in French). — I think we may therefore say that there is the very rapid circuit breaker which opens in terms of the current and the circuit breaker which opens in terms of the derivative of the current in regard to the time.

Mr. Japiot (in French). — What Mr. Bianchi has said concerning the ultra rapid American circuit breaker is true as regards the locomotive circuit breaker, but the same type may be adjusted to act as a function of the derivative of the current.

We have the same type of circuit breaker on certain locomotives and in the sub-stations. It is adjusted in terms of the current on the locomotives and in terms of the derivative of the current on the feeders of the sub-stations.

We have made short-circuiting experiments on locomotives provided with the two systems of protection mentioned by Mr. Bianchi : rapid circuit breaker or ordinary contactors.

Oscillograph tests gave exactly the same results.

For both types of apparatus, a resistance was first inserted, the resistance being smaller, however, for the rapid circuit breaker.

In both cases, the short circuit was broken when the current rose to about 3 500 or 4 000 amperes, and the overvoltage reached 100 %.

Mr. Bianchi (in French). — I am very grateful to Mr. Japiot for his information which may be compared with the data furnished on this point by the Japanese reporters, Messrs. Azakura and Imaidzumi. The latter also found that the overvoltage rises to 100 %.

It seems to me that we may conclude from this that the traction motor and all the appliances of the continuous current locomotive are subjected to voltages which at times are double the ordinary voltages. This question could be brought up again in discussing traction motors, that is, the conditions which these motors ought to satisfy on high power continuous current locomotives.

The President (in German). — After what has been said, it will be sufficient to examine the control apparatus of *single-phase* locomotives, since there are no

differences of opinion concerning the continuous current and three-phase current locomotives.

We now come to point 9 : *Equipment.*

Mr. Bianchi :

Equipment. — Seeing that opinions agree on the best system of equipment for continuous current and three-phase current locomotives, it may be asked which is the best equipment for single-phase locomotives (electropneumatic or electromagnetic contactors, cylinders operated by servomotors, etc.).

Mr. Weiss (in German). — The Swiss Federal Railways employ contactor equipments and linear contact apparatus. Both give good results.

The President (in German). — The Reichsbahn has abandoned control by electro-pneumatic contactors because it was impossible to ensure the necessary tight fit of the pistons in the cylinders at reasonable maintenance costs. On the other hand they are employing electro-magnetic contactors with good results. For some years the arrangement of these appliances has been such as to ensure reliability of operation whilst occupying the least possible space. They are easily dismountable into their constituent parts and the same applies to their assembling. In addition, the Reichsbahn employ also the linear contact equipments mentioned by Mr. Weiss. They function very well and their construction and maintenance are simple : the driver has however to employ more force to operate them than with contactor equipment. We also possess another very useful equipment which is the control by precision regulator described in detail in my report (p. 1337 of the *Bulletin* for April 1930). It is greatly favoured by the staff.

We now come to point 10 : *Transformers and traction motors.*

Mr. Bianchi :

Transformers and traction motors. — The general question affecting all types of traction motors (tests to ascertain the power, heating, dielectric rigidity, etc.) are now under consideration by several committees so that they need not be dealt with at this Congress.

It may, however, be desirable to state the opinion expressed in the different reports that if on the one hand the continuous current, single-phase and three-phase motors recently built give satisfactory results as regards heating, commutation, specified power, it appears still necessary to consider improvements intended to reduce the defects in the insulation.

Mr. Leboucher (in French). — We all know the importance of the insulation from the point of view of certainty of operation, but unfortunately some builders are trying to force us to accept motors which have insufficient insulation.

What Mr. Bianchi desires is that the Congress should pass a vote in favour of really good insulation. I think that all the operators here present are entirely in agreement with such a wish being approved.

Mr. Cortez Leigh. — The question of insulation and commutation on D. C. motors is an important one. It behoves everyone to insist on better quality of insulation; this will lead to a direct saving on the spare plant required, and therefore the capital to be invested. One should see that the various Committees dealing with these problems should have these matters prominently before them. This is one of the most important subjects touched upon in the summary.

The President (in German). — The examination of point 10 being finished, we shall now deal with point 11 relating to the *safety of the staff*.

Mr. Bianchi :

11. As regards the *safety of the staff* in service on electric locomotives it would appear desirable to adopt uniform regulations and arrangements in all countries. The discussion could therefore deal with the following points :

What are the arrangements to be provided to prevent the staff accidentally coming in contact with the current collectors and with conductors under tension ?

What arrangements are to be provided for the safety of the staff against explosions or fire of apparatus containing oil?

The President (in German). — These are considerations of principle. The use of protective devices should not be carried too far. It may easily happen that the construction of the equipment then becomes too complicated, and possible sources of defects arise resulting in exactly the contrary effect to that desired. Thus, for many years now, we have given up placing the oil circuit breaker and other high tension elements in a special compartment. Also, the contactors in the motor room are not protected by gratings or any other means against accidental contact. Anyone who has to enter a motor room must be supposed to be acquainted with the danger to which he is exposed if he infringes the simple regulations concerning the operation of the equipment.

We will confine ourselves, therefore, to an examination of the safety measures which are recommended or which have already been adopted as regards the staff of electric locomotives.

Mr. Bianchi (in French). — I shall explain briefly the devices which have been adopted on the new locomotives now in course of construction.

As regards the pantographs, it is quite right to have a definite regulation forbidding persons to climb on the roof of the locomotive. Nevertheless, it is true that the anxiety to avoid any delay to the train sometimes prompts the staff to break the regulations despite the danger which may prove fatal. Under these conditions, while continuing to prohibit climbing on the roof, we have provided an escape cock for the air of the pantograph which is so adapted that the driver cannot get onto the roof without previously having opened this cock. Even if, inside the locomotive, anything is done in order to supply air to the pantograph, the latter does not lift.

In a second arrangement, the pantograph is earthed whenever it is lowered.

Also, access to the high tension section is covered by means of a blocking key, so that opening the door earths the locomotive.

Mr. Cortez Leigh. — My Company is taking the precautions which Mr. Bianchi has mentioned, and the practice — although it only has motor cars — is to have both fuses and circuit breakers for protective purposes; and the regulations for the working of the pantographs are on the lines which Mr. Bianchi has stated. There is also protection on the cab of the car and it is not possible for men to touch any dangerous apparatus. With regard to people working on the lines, the regulations from a general standpoint make it impossible for anyone to touch the wires either from the electric or other trains, etc. Every necessary precaution is taken, and special instructions are in force in Great Britain.

— At the request of the President, Mr. Bianchi reads point 12.

12. Although on the *electric locomotives intended to run at very high speeds* [above 100 km. (62 miles) per hour], the individual axle drive by gearing has been adopted in recent construction with raised motors rigidly fastened to the frame and four-wheel leading bogies, it may be asked if, for future building of this type of locomotive, the application of other systems of drive or single axle leading trucks is being considered.

The President (in German). — Since nobody desires to speak, we shall proceed to point 13.

Mr. Bianchi :

13. As regards *regeneration of energy or electric braking*, every one agrees upon the importance of using one or the other system in order to increase the safety of the ordinary brakes on lines with heavy gradients.

The possibility of using regeneration or electric braking is always subject either to the advisability of not making the locomotive too complicated, or to financial considerations.

Mr. Bals (in French). — In regard to point 13, I should like to know if, from the point of view of the regeneration of energy, fairly simple designs have been developed by which regeneration can be used at the present time in the case of single-phase current.

Mr. Weiss (in German). — The reply is in the affirmative. The Swiss Federal Railways have provided devices for the regeneration of energy on locomotives running over long and steep gradients. Their behaviour leaves nothing to be desired.

The President (in German). — May I refer Mr. Bals to my report? He will find there detailed information on the electric braking employed by the Reichsbahn.

Mr. Bianchi. — As regards the importance of regeneration from the point of view of consumption of power, I think that Mr. Hinglais, of the Morocco Railways, can give us some very interesting data regarding regeneration on his Company's railway.

Mr. Hinglais, Morocco Ry. Co. (in French). — The importance of the regeneration of which Mr. Bianchi was speaking, is due entirely to the fact that on the lines belonging to the Morocco Railway Company, the ascending and descending loads do not balance one another. The ascending trains have 650 t. (640 Engl. tons) of trailing load and the descending trains 2 100 t. (2 066 Engl. tons). Consequently, as the gradient is continuous, a very considerable regeneration is obtained which attains up to 30 %. Of course, it is not all utilised because, the line being single, the power regenerated by the descending trains cannot be utilised by the ascending locomotives. Still, we get a consumption per 100 tkm. hauled, which is very small for a relatively small traffic.

The President (in German). — We now come to point 14 relating to the *so-called dead man's handle*.

Mr. Bianchi read this point :

14. As regards the so-called dead man's handle more especially used on multiple unit trains, three types may be distinguished amongst those most used :

a) arrangements whereby the driver has to press a button or pedal all the

time without causing the current to be shut off and the brakes to be applied;

b) devices as above mentioned, except for the difference that the action on the circuit breaker and the brake takes place after a certain interval of time previously determined;

c) devices as above, which come into action after the vehicle has travelled a certain distance regulated beforehand.

In view of the tendency to operate rail motor coaches or locomotives with a single man, a discussion on the different devices would be interesting, both as regards safe working and the comfort of the staff.

Mr. Weiss (in German). — We have two systems on the Federal Railways. In one of them, the appliance comes into operation as soon as the pedal or button is released, but only in the case where the speed exceeds 20 km. (12.4 miles) per hour. We are using this device on our rail motor coaches. In the other system, the device becomes operative when the locomotive has travelled a certain predetermined distance after the driver has released the pedal.

Mr. van Lessen. — May I ask why different systems have been chosen in Switzerland for the motor coaches and for the locomotives? On the Netherlands State Railways, we have placed the safety button on the handle. So that the driver should not become fatigued, we have provided a pedal in parallel, for the moment as an experiment, but we are intending to equip all the vehicles with it.

Mr. Weiss (in German). — In the first place, an appliance which I spoke about and which operates according to the speed was introduced on the rail motor coaches. It has one drawback. If the 20-km. (12.4 miles) limit is exceeded, the driver cannot move. That is why, for the new vehicles, we preferred to adopt the second system, in which the appliance is independent of the speed, thus permitting the driver to move on.

We also have the two devices in conjunction, the pedal and the button, so that the driver is free to use either the one or the other.

The President (in German). — At the present moment, the Reichsbahn are carrying out rather extensive tests with three different systems. All three appear to be satisfactory, but we shall give the preference to the simplest of them.

Mr. Cuttica (in French). — The Italian Railways have placed under consideration a device proposed by the Westinghouse Company. Instead of providing a button which has to be pressed to enable the locomotive to run, this appliance is provided with a lever which the driver has to move from the left to the right, for example, every 5 or 10 seconds. This device is stated to have the advantage over the button that it cannot be locked by the driver. It is possible that tests will be made with this appliance.

Mr. Bianchi (in French). — I should like to point out, however, that it is not desirable to compel the driver to make a continual and tiring movement. It is with this object that we are also going to test a device in which the driver has no movement to make and which operates on the principle of the shifting of the centre of gravity of the locomotive driver.

The President (in German), — Does anyone still wish to speak on this subject?

As no one replies, we shall pass to point 15 : *Operation*.

Mr. Bianchi (in French). — This is simply an observation :

15. *Operation.* — The data on operation contained in the different reports are not enough for any general conclusions to be drawn therefrom, either on the mileage possible with the different types of locomotive between general repairs, or on the number of service defects arising during a given mileage.

It is however possible to affirm that the electric locomotive, as a result of the improvements made during the last years in the electrical part, already gives better results both as regards mileage and regularity of service than the steam locomotive.

— This paragraph did not give rise to any remarks.

The President (in German). — The discussion on question VII is closed and I shall now ask Mr. Bianchi to read us his draft summary.

Mr. Bianchi (in French). — This is the summary which I propose in agreement with my colleage, Mr. Leboucher :

« 1. The Congress finds in the first place that the electric locomotive does not show the uniformity of design that the steam locomotive already presented a few years after its invention and in which direction it has since continued.

« 2. The different methods adopted for the transmission of power from the motors to the wheels and for the arrangement of trucks, have in almost all cases given satisfaction with the exception, perhaps, of the gearless drive as built up to the present.

« The Congress recommends, however, to the Railway Companies having in service locomotives with motors suspended by the nose to ascertain, by means of methodical tests, whether at high speeds this type of locomotive, in regard to its action on the track, really is worse than the others.

« The Congress recognises that, as regards locomotives without coupling rods and with the motors completely carried on the frame, all other things being equal, a heavier weight per axle can be allowed than in the case of locomotives with reciprocating masses, not being completely balanced, as most steam locomotives. »

Mr. Japiot (in French). — I consider that it is scarcely possible to make any statement on the gearless locomotives in the absence of our American colleagues. So far as I know, there is only one gearless locomotive in the world which is not in service on American railways, and it also comes from an American builder.

Mr. Cardon (in French). — I entirely support Mr. Japiot's proposal.

The gearless locomotive which has been discussed at our meetings is in service on the Orleans Railway.

Even though the behaviour of this locomotive in service at speeds slightly less than 120 km. (76 miles) per hour may be open to criticism, there is nothing which would enable one to assert that this is due to the fact that it is gearless.

In point of fact, it must be stated that when it was delivered, our criticisms were directed towards the arrangement of its bogies, which had to be modified. Since the modifications which were made proved to be insufficient, a more complete rearrangement was carried out. Instead of a unit comprising two electric semi-locomotives, and in a way reminiscent of 2 ten-wheel locomotives connected together at their trailing end by means of a central coupling, we have now two

coupled motor trucks each comprising, as before, a bogie and three driving axles but supporting this time, each by a pivot, a single body. The behaviour of the locomotive rearranged in this way is distinctly better than the original locomotive with modified bogies. However, further improvements are still necessary, and we are continuing our researches with a view to defining and realising them.

It will be seen, however, that our present experience in no ways enables us to assert that it is the gearless device which is involved and not the design of the motor trucks.

We are therefore not in a position to make any conclusion, especially an unfavourable one, in regard to the value of this gearless arrangement.

Mr. Bianchi (in French). — I think that we may delete the reference to gearless locomotives, the last part of the first paragraph of point 2, so that the latter now becomes :

« 2. The different methods adopted for the transmission of power from the motors to the wheels and for the arrangement of trucks, have in almost all cases given satisfaction. »

The President (in German). — I consider it desirable to appoint a sub-committee to propose an agreed text at our next meeting.

I think, however, that it would be useful to continue to examine the summaries so as to inform the sub-committee of the amendments which it would be desirable to make.

In this direction, we should examine the second paragraph in which we recommend to the Railway Companies to make methodical tests in order to determine, whether at high speeds the motors suspended by the nose present disadvantages on account of their action on the track. It seems to me that we are fairly unanimous regarding the wish to be expressed with a view to continuing the tests.

Mr. Weiss (in German). — The third paragraph is not quite clear. Electric locomotives in general, apart from a few exceptions of locomotives with coupling rods, as for example the Italian locomotives, allow of an increase in the load per axle, because there is no other additional force during rotation except in the case of inclined coupling rods.

In the Westinghouse type, there are also additional forces and the centre of the two wheels of the driving axle and of the hollow shaft are not identical There are additional loads or reduced loads on these axles. That is why the Federal Railways have not allowed the weight of 20 t. (19.7 Engl. tons) as for the other locomotives, but only 18.5 t. (18.2 Engl. tons) per axle.

Mr. Leboucher (in French). — The remark made by Mr. Weiss is correct as regards what may be called « spring drives ». In what may be called « free translation » drives, the axle moves freely perpendicularly without adding any additional load to the axle when the axle moves relatively to the hollow shaft.

The remark made by Mr. Weiss applies to the Westinghouse, Sécheron and other locomotives, in which there are in fact two suspensions working in parallel.

As there are two suspensions, it would seem that a slightly greater flexibility might be given to the main springs in order not to be obliged to reduce the load per ton of each axle. It should be possible to do this in the construction of the locomotive, by slightly reducing the stiffness of the springs.

Mr. Weiss (in German). — I do not agree.

Mr. Bianchi (in French). — I also agree with Mr. Weiss' remark, but I think that the variations in the axle loads should not be of the same magnitude as those met with in locomotives with coupling rods. In locomotives having reciprocating motion, 12 to 15 % of the masses are not balanced, while in the cases mentioned by Mr. Weiss, I think that it is merely a matter of variations of the order of 10 % at the most.

The President (in German). — The Amendments Committee will therefore also deal with the wording of the third paragraph of point 2. I shall ask Mr. Bianchi to read point 3 of the summaries.

Mr. Bianchi (in French). — « 3. From the electrical point of view, the Congress appreciates that as a result of the improvements in recent years and of the arrangements which have been made to protect the staff against accidents, locomotives of different types give complete satisfaction both as regards their working as of the comfort and safety of the staff.

« In particular, recently built continuous current single phase and three phase traction motors give complete satisfaction as regards heating, power and commutation.

« The Congress, however, calls attention to the need for following up investigations and improvements relating to the insulation of the different parts of the motors with a view to reducing the damage which occurs from time to time from this cause.

« The Congress trusts that attention will be given to these points when drawing up the new technical specifications at the present time under consideration by several International Associations. »

Mr. Nordmann, Deutsche Reichsbahn Gesellschaft (in German). — I think that there is still something lacking in our summary. In the first paragraph of article 3 we speak of the satisfaction given to us by different types of locomotives from both the point of view of regularity of working and that of the comfort and safety of the staff, and then further on we ask that studies and improvements relating to insulation should be continued with a view to reducing damage which still occurs rather frequently.

It is scarcely logical to speak on the one hand of the satisfaction which we experience in regard to the safety of the staff and then to go on to say that is is desirable to continue studies with a view to avoiding accidents.

Perhaps the affirmative or optimistic side of the first paragraph might be somewhat diminished.

The President (in German). — I had not failed to remark this contradiction. On the other hand, the experiments made by the different Administrations are not always the same and I would say to Mr. Nordmann that no mechanical creation ever offers absolute safety. However, in order to take into consideration the remarks which have been made, summary 3 might also be referred to the Amendments Committee.

In spite of the late hour, I should be glad if we could also deal with point 4 so that the Amendments Committee may know our opinions thereon.

Mr. Bianchi read point 4 of his summary as follows :

« 4. The Congress also notes that as

regards mileage and regularity of working, recently built electric locomotives give results distinctly superior to those obtained with steam locomotives.

« It requests the various Companies and Administrations to regularly and freely publish the results of operation on their electrified lines with a view to helping other administrations in the study of new applications of electric traction. »

Mr. Bals (in French). — It seems to me that from the point of view of regularity of working there is no necessity to attribute to them such superiority over the latter. I therefore propose that the question of regularity of working be deleted.

Mr. Bianchi (in French). — In comparing the two types of locomotives, it is necessary to consider not only the mileage but also the power in tonne-kilometres hauled. The results have been altogether in favour of the electric locomotive.

Mr. Bals (in French). — I do not doubt Mr. Bianchi's conclusion but it seems to me that in speaking of regularity of working two things occur to one: first the regularity in keeping to the timetables and then the number of untoward incidents during running, that is to say, the mishaps which occur and which result in unbooked stops.

It seems to me that from this point of view, the steam locomotive has attained a remarkable degree of perfection; at all events, it was from this point of view that I wished to raise the question.

Mr. Nordmann (in German). — In comparing the tonne-kilometres hauled, it is obviously necessary to compare units of the same or nearly the same power.

Mr. Wagner, Deutsche Reichsbahn Gesellschaft (in German). — This summary is worded in a form that would definitely establish the superiority of electric traction. It would become one of the most important resolutions of the Congress. A conclusion of such importance could only be voted if detailed statistics and numerical data were available, and to my knowledge these do not exist. We only possess data regarding long runs made by electric locomotives.

I think that all that we can do is to invite the Administrations to compile the necessary statistics for the next Session and to elucidate with figures the relations between electric locomotives and steam locomotives.

Sir Henry Fowler, London Midland & Scottish Railway. — I wish to strongly support what Mr. Wagner has said. We have not discussed this matter from a steam locomotive standpoint, but only as far as recent electric locomotives are concerned, and I suggest that all reference to the steam locomotive be cut out of this item.

The President (in German). — I should like to ask if we could not come to an agreement by deleting the words « regularity of working ». I think that Mr. Bianchi would accept this deletion.

Mr. Bianchi. — Yes.

Sir Henry Fowler. — I formally move that the reference to steam locomotives be withdrawn from clause No. 4.

The President (in German). — I think, however, that as regards distances

run we have statistical data proving that the conditions are more favourable for electric locomotives than for steam locomotives. I do not see why we should not say so.

Sir Henry Fowler. — I should like to know what are the statistics on which that assertion is based.

Mr. Wagner (in German). — I second Sir Henry Fowler's motion. I also think that it would be premature to decide definitely in favour of the superiority of the electric locomotive, even as regards distances run.

We might find ourselves tomorrow in face of other facts which prove the contrary.

Mr. Bals (in French). — It seems to me that the point of view of Sir Henry Fowler and Mr. Wagner in this matter ought to be supported. The steam locomotive at the present moment is in a stage of evolution which does not permit us to involve the future. Conclusions on this matter would be premature.

I should therefore like to support very strongly the point of view of Sir Henry Fowler, and to recommend the deletion of the comparison with steam locomotives.

Mr. Bianchi (in French). — The same may be said of electric locomotives.

Sir Henry Fowler. — I wish to reiterate my formal proposition that any comparison with the steam locomotive in article 4 be withdrawn.

— The majority of the Meeting was in favour of this proposition.

Mr. Bianchi (in French). — No. 4 would be worded therefore as follows :

« 4. The Congress also notes that from the point of running and regularity of service, recently constructed electric locomotives give satisfactory results.

« It requests the various companies... »

The President (in German). — The Amendments Committee will take this deletion into account in the final wording.

— The Section agreed on this point.

The President (in German). — We shall now proceed to the constitution of the Amendments Committee which will suggest the text of the summaries.

Mr. Wagner (in German). — As reference has been made in the summaries to steam locomotives, it would be logical to include on the Committee a representative who is specially competent in this matter.

The President (in German). — The Amendments Committee will then be composed as follows : Mr. Bianchi, President, and Mr. Leboucher for electric traction; Sir Henry Fowler and Mr. Nordmann for steam locomotives.

Does everybody agree with the Committee being so composed ?

— The Meeting signified its agreement by applause.

— The Meeting then closed and the end of the discussion was postponed to 9.30 a. m., Wednesday morning, 14 May.

Meeting of the 14 Mai 1930 (morning).

Mr. WECHMANN in the Chair.

The President (in German). — I declare the meeting open and shall ask Mr. Bianchi to read the summaries as drawn up by the Committee which we appointed at the last meeting.

Mr. Bianchi (in French). — Summaries :

« 1. The Congress finds in the first place that the electric locomotive does not present the similarity of arrangement that the steam locomotive already had a few years after its invention and in which direction it has since continued.

« 2. The different methods adopted for the transmission of power from the motors to the wheels and for the arrangement of trucks, have in almost all cases given satisfaction.

« The Congress, however, recommends to the Railway Companies the carrying out of methodical trials, with a view of determining whether, at high speeds, electric locomotives with motors suspended by the nose have a more injurious effect on the track than other types.

« As regards locomotives without coupling rods, and with motors completely suspended from the frame, the Congress recognises that, all other things being equal, one can adopt a heavier weight per axle than with locomotives in which certain masses are reciprocating, not being completely balanced, — as is the case in fact with the majority of steam piston locomotives.

« 3. From the electrical point of view, the Congress appreciates that as a result of the improvements in recent years, and having in view the arrangements which have been made to protect the staff against accidents, locomotives of different types give general satisfaction from the point of view of their functioning, and give perfect protection to the staff.

« Traction motors in particular at present give complete satisfaction as regards heating, power and commutation.

« However, the Congress calls attention of designers to certain details of construction such as the insulation of various parts of the motors, etc., with a view to reducing damage which occurs from time to time.

« Consequently, the Congress trusts that attention will still be given to these points with the object of developing new technical specifications, which at the present time are being considered by several International Associations.

« 4. The Congress also notes that from the point of running and regularity of service, recently constructed electric locomotives give satisfactory results.

« It requests the various Companies and Administrations to regularly and freely publish the results of operation on their electrified lines with a view to helping other administrations in the study of new applications of electric traction. »

The President (in German). — Does the Meeting approve of the text which has just been read ?

— No objection being raised and no one wishing to speak, the wording was considered as adopted.

DISCUSSION AT THE GENERAL MEETING.

Meeting of the 15 Mai 1930 (morning).

PRESIDENT : MR. JOSÉ GAYTAN DE AYALA.
GENERAL SECRETARIES : MESSRS. P. GHILAIN AND A. KRAHE.
ASSISTANT GENERAL SECRETARIES : SIR HENRY FOWLER, K. B. E., MESSRS. P. WOLF AND J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary*. — There are two questions left for us to examine in order to complete the technical work. First of all, we have the summaries adopted by Section II for Question VII. I propose that you approve of the text presented.

Has anyone any remarks to make ?

— No objection was raised.

The President. — The final summary is therefore as follows :

Summary.

« 1. The Congress finds in the first « place that the electric locomotive does « not present the similarity of arrange- « ment that the steam locomotive already « had a few years after its invention and « in which direction it has since con- « tinued.

« 2. The different methods adopted for « the transmission of power from the « motors to the wheels and for the ar- « rangement of trucks, have in almost all « cases given satisfaction.

« The Congress, however, recommends « to the Railway Companies the carrying « out of methodical trials, with a view « of determining whether, at high speeds, « electric locomotives with motors sus- « pended by the nose have a more injuri- « ous effect on the track than other types.

« As regards locomotives without coup- « ling rods, and with motors completely « suspended from the frame, the Con- « gress recognises that, all other things « being equal, one can adopt a heavier « weight per axle than with locomotives « in which certain masses are recipro- « cating, not being completely balanced, « — as is the case in fact with the ma- « jority of steam piston locomotives.

« 3. From the electrical point of view « the Congress appreciates that as a re- « sult of the improvements in recent « years, and having in view the arrange- « ments which have been made to pro- « tect the staff against accidents, loco- « motives of different types give general « satisfaction from the point of view of « their functioning, and give perfect pro- « tection to the staff.

« Traction motors in particular at pres- « ent give complete satisfaction as regards « heating, power and commutation.

« However, the Congress calls attention « of designers to certain details of con- « struction such as the insulation of va- « rious parts of the motors, etc., with a « view to reducing damage which occurs « from time to time.

« Consequently, the Congress trusts

« that attention will still be given to
« these points with the object of deve-
« loping new technical specifications,
« which at the present time are being
« considered by several International As-
« sociations.

« 4. The Congress also notes that from
« the point of running and regularity of
« service, recently constructed electric
« locomotives give satisfactory results.

« It requests the various Companies
« and Administrations to regularly and
« freely publish the results of operation
« on their electrified lines with a view
« to helping other administrations in the
« study of new applications of electric
« traction. »

— This final summary was ratified by the General Meeting.

[625 .23]

QUESTION VIII.

ALL-STEEL COACHES. COMPARISON WITH VEHICLES BUILT OF WOOD.

Preliminary documents.

1st report (Belgium, France and their Colonies), by Messrs. LANCRENON and VALLANCIEN. (See *Bulletin*, July 1929, p. 1023 or separate issue No. 10.)

2nd report (other countries, except America, the British Empire, China, Japan and Germany), by Messrs. M. GARCIA-VARO and P. FRAILE. (See *Bulletin*, September 1929, p. 1771 or separate issue No. 23.)

3rd report (America, British Empire, China and Japan), by Mr. E. J. H. LEMON. (See *Bulletin*, June 1929, p. 589 or separate issue No. 5.)

4th report (Germany), by Mr. E. DAHNICK. (See *Bulletin*, February 1930, p. 635 or separate issue No. 63.)

Special Reporter: Mr. LANCRENON. (See *Bulletin*, May 1930, p. 1422.)

DISCUSSION BY THE SECTION.

Meeting held on the 14 May 1930 (morning).

MR. WECHMANN IN THE CHAIR.

The President (in German). — I call upon Mr. Lancrenon to give us a brief outline of his special report published in the *Bulletin* of May 1930, page 1422.

Mr. Lancrenon, *Special Reporter*. — If the use of metal in railway rolling stock bodies is of comparatively recent introduction in Europe, it should be remembered first of all that the American railways have used it for nearly thirty years, and that they have in consequence, a much larger experience of it than we have. I hope that among the delegates here present there may be some representatives of those railways and that they will enable us to pofit from the fruit of that experience.

I may say however, that the European builders have not followed the lines traced by those who forestalled them. When it was found that such high tare weights as those allowed in America could not be permitted under their own traffic conditions, these builders have taken steps to obtain the same degree of safety, the fundamental reason for the designs, without greatly exceeding with this new stock, the tare weights of the wooden vehicles previously built.

The two main considerations governing the designs of all-metal stock are, in fact, on the one hand, the desire to give the public the greatest possible safety, and on the other the need to reduce to a minimum the dead weight per seat.

We also find very definitely that the present tendency, on European railways, is to replace the separate frame usually of the fish bellied design, carrying a light framed body, in use on the American systems, by a built-up metal girder in which the body and the frame contribute equally to the strength of the whole.

Since my report was published I have learnt that the International Sleeping Car Company, practically the only one in Europe to adopt the American system, have just started to put into service new series of vehicles constructed on the built-up girder principle.

The efforts to reduce the dead weight of the stock have been successful and the tables published in the reports and summarised on page 1425 of the special report, show that the weight per spuare metre of surface covered which often exceeds 1 000 kgr. (205 lb. per sq. foot) for vehicles with a separate frame is only from 700 to 800 kgr. (143 to 164 lb. per sq. foot) for carriages in which the body takes its part in the strength of the vehicle. Even in Germany where the old carriages had, it is true, high tares, all-metal carriages have been constructed lighter than those they were built to replace.

The special report is in five parts :

Utility of the all-metal construction;
Types of carriages;
Methods and materials of construction;
Interior fittings;
Comparison with wooden carriages.

One or two of the summaries given in the special report apply to each one of those sections.

Having regard to the short time at our disposal, I propose, Mr. President, at once to examine these summaries. During the examination, which, I trust will not raise any difficulties, since I have had the pleasure of finding that the conclusions arrived at by the four reporters are identical, it will be possible to have an interesting exchange of ideas on the various conditions used by each to solve the different problems which arise in all-metal construction.

So that the order of the discussion should be, however, really logical, summary 2, should be considered after summary 6.

The President (in German). — I recommend that the discussion proceed in the order in which the conclusions are presented, with this modification however, that as Mr. Lancrenon suggests, the second summary be joined to the sixth. Let us now examine point No. 1, which reads as follows :

Considerations of safety are in themselves sufficient to justify the use of metal construction for coaches to be built.

Mr. Lancrenon (in French). — We wished to emphasise the « considerations of safety » and that is why the first conclusion has been drawn up in this form, but it should be noted that metal construction has other advantages.

As the special report points out, the substitution of rivetted or welded joints for the old fashioned methods with wood gives at one and the same time greater comfort to the passenger, longer life to the rolling stock, and consequently a reduction in depreciation charges.

Furthermore, the use of steel, which can be obtained in unlimited quantity,

enables us to avoid the great difficulties we are beginning to find in getting wood; indeed, I think that that is one of the reasons which have urged the Americans to go ahead so quickly with metal construction.

Finally the general use of metal facilitates the mass production of standardised parts.

Mr. Gresley, London & North Eastern Ry. — The wording of article 1 of the summaries drawn up by Mr. Lancrenon is, I am afraid, hardly acceptable to the English railways, in that it states that considerations of safety are in themselves sufficient to justify steel coaches. This does not take into account any question of weight and cost, and these may be twice as much for steel as for wood. London & North Eastern experience has shown that the steel coaches we have, and which are in every respect identical with wood, so that passengers in the vehicles cannot tell whether they are in a steel coach or a coach built of wood, cost considerably more than the wood ones and are heavier, and we cannot agree that coaches can be built as cheap and as light of steel. The weight of the coach, of course, depends on the thickness of the metal; for instance the sides can be made very thin, and it can be made as light as a wooden coach but it would not be as strong, and I therefore wish to suggest that point No. 1 be amended.

The experience in respect to steel carriages in America and in Europe has been largely with carriages of the open type, and solid sides, and doors at each end. In England, such a carriage does not meet all our conditions, and the Traffic Department requires the building of carriages with corridors, etc.

We have had no experiences as yet to speak definitely with regard to the life of a steel coach, and it is, at the moment, difficult to say whether its life will be longer than that of a coach made of teak, which latter is perfectly sound after a great number of years.

I therefore suggest the following wording for summary No. 1 :

« In those Countries in which the operating conditions permit the adoption of all-steel carriages, experience has shown that considerations of safety sufficiently justify the adoption of this construction for new stock. »

Mr. Dähnick, *Reporter* (in German). — Ever since 1912 the Reichsbahn has used metal carriages, both the separate compartment and the side corridor types.

Subsequently for safety reasons, the compartment type was given up, but we found that even where the latter type is used the weight of the metal carriage is no greater than that of a wooden one, of equal strength of course.

I have, moreover, no objection to make to Mr. Gresley's amendment.

Mr. Koller, State Railways, Czechoslovakia (in French). — Mr. Dähnick has spoken of safety and of weight and I should like to know if, these two conditions being realised, the price is not considerably higher.

Mr. Dähnick (in German). — In adopting the metal carriage, we have naturally made certain improvements and additions to the fittings which are independent of the nature of the vehicle. Taking this into account, and also the fact that after the war the level of prices went up 50 % it can be said that metal

carriages have not involved an increase in the first cost of rolling stock.

Mr. Bianchi, Italian State Rys. (in French).— I think that Mr. Lancrenon's summary could be retained if we say that the considerations of safety are « generally » sufficient.

Mr. Lancrenon. — Mr. Gresley told us a little time ago that it was difficult to build metal carriages with side doors. Mr. Dähnick has just told us that he has built such stock and furthermore Mr. Gresley has seen several on the French Nord System on which a considerable number of third class carriages with side doors have been built. Consequently I do not think that the objection can be taken as ruling out the summary.

So far as I am concerned, I would willingly support Mr. Bianchi's suggestion by saying « are generally sufficient ».

Mr. Lemon, *Reporter*. — I think that first of all one must try to be clear in one's mind as to what one is endeavouring to achieve. The Americans have gone in for very heavy all-steel coaches in an endeavour to try and reduce fatalities in cases of accidents. Metal coaches can be constructed lighter than wooden ones, and I should like to know if anyone has any information as to what stresses the metal coaches will withstand. As regards the different speeds which are met with, for example, a light steel coach may be safe at 20 miles per hour, but if it is in a collision at 50 miles per hour it may collapse. I should like to ask Mr. Dähnick whether, on the German Railways, they have had any experience of metal carriages in collision, as I am rather dubious as to what would happen if people were imprisoned between compartments. I entirely agree with the amendment which Mr. Gresley has put forward.

The President (in German). — Can any delegate give us any information on the behaviour of the different types of carriages in case of collisions ?

Mr. van Schouwenburg, Dutch East Indies Railway Company (in German). — On our railway, in the Dutch East Indies, we had a bad collision between wooden carriages with separate compartments and side doors. A heap of debris was all that remained. Of course no Railway Administration can afford the luxury of repeating such collisions with other types of rolling stock and at different speeds.

Unfortunately there is no representative of the Dutch Railways in the room. Had there been one, be could have given you information about an accident which happened in Holland to some steel electric automotors : two trains travelling at high speed, collided; the metal coaches, with end doors, suffered comparatively little damage.

As regards the shock produced when two trains collide end on, I am able to tell you that our Company made buffer trials with two loaded covered goods steel wagons, of a total weight of about 25 tons. One of them was held by its brakes, and the other run in to it at a speed of about 12 km. (7 1/2 miles) an hour. The observed pressure between the buffers was about 90 t. (88.5 Engl. tons).

Mr. Dähnick. — We think that for equal weight, the safety is the same. In fact, steel is a constructional material which lends itself much better than wood to those forms which absorb bending

moments. We have even been able to reduce the weight while giving a considerable increase in strength. We have not made trials under collision conditions, but accidents have occurred which were very instructive from this point of view. In an accident which occurred near Buer (Rhineland) a restaurant car of the Mitropa, with seating accomodation for 42, 41 of which were occupied, fell down the embankment and overturned. The passengers escaped with slight wounds. The same results were observed in the Leiferde accident. Wooden coaches telescope into one another while steel vehicles buckle up under the shock. With the latter, telescoping does not occur, especially if the coaches are so constructed that the bodies take their share in the strength of the whole. In every case, the safety of the passengers is considerably increased, when metal carriages are used.

Mr. Renevey, Paris Lyons & Mediterranean Ry., Algerian Lines (in French). — The opinion of the French systems is very decided on the increased safety afforded by metal carriages, and our opinion like that of the German delegation, is based unfortunately, on accidents which have occurred. We find in Mr. Lancrenon's report photographs of coaches which have collided at a speed of 60, and even of 80 km. (37 and 50 miles) an hour, and where the damage to the body has scarcely gone further than 1 m. (3 ft 3 3/8 in) from the head stock.

In the vehicle, a passenger coach, which was run into at Vulaines, not a pane of glass was broken in the coach, and the damage scarcely extended as far as the lavatory, *i. e.*, did not go beyond the vestibule end.

In the mail van run into at 80 km. (50 miles) an hour, the damage was much the same.

The President (in German). — The weight of the coach and its behaviour in collision must evidently depend on the methods of construction, and on the materials employed. One can seldom reach perfection at the first attempt. We have an example of this in the motor coaches and trailers of the Berlin Metropolitan. In the first form they weighed 45 and 34 t. (44.3 and 33.5 Engl. tons) respectively. I ought to say that Mr. Dähnick had not had anything to do with the designs of these coaches.

In the second design, the weight was reduced by 18 %.

We have, so far, no grave accidents in which these carriages have been concerned, to quote, but in consequence of the oversight of an engineer who was making trial runs, a train ran into a buffer stop on one occasion. Eye witnesses estimated the speed at 40 km. (25 miles) an hour. While the electrical gear under the body was stripped off, the body itself remained intact : not a window was broken.

Mr. Wagner, Deutsche Reichsbahn Gesellschaft (in German). — I would like to return to Mr. Lemon's enquiry concerning the results obtained in America.

Perhaps one of the American delegates can give us some information about the accidents which occurred in their country ?

As no American delegate appears to be present, I will take the liberty of saying a few words on the subject. About two years ago whilst in America, I had the opportunity of studying the behaviour of locomotives and vehicles in collisions on a certain number of railway systems,

and I can sum up as follows, the information I gathered. The American passenger coaches have no side doors but only end doors and a very rigid end vestibule, so that they cannot be telescoped. Furthermore, they are fitted with an arrangement which prevents any one coach from mounting another. In all the accidents which came to my notice, the tendency which seems to manifest itself is the following : whilst formerly wooden coaches as a rule stayed on the rails and were telescoped, steel coaches are usually derailed at once. They end in a zigzag position, or in a big semi-circle alongside the track. At the same time the momentum is destroyed by the carriages sliding over the ground.

The President (in German). — I believe I am correct in saying that a draft has been made such as will receive the maximum support of the Section on the subject of point No. 1.

I will ask Mr. Lancrenon to be good enough to let us have it.

Mr. Lancrenon (in French). — Here is the text of the recommendation, which Mr. Gresley has agreed with us :

« In those countries in which the operating conditions permit the construction of all steel carriages, experience has shown that conditions of safety sufficiently justify the adoption of this construction for new stock. »

The President (in German). — I ask the Assembly to signify its agreement with this draft. No objections having been raised, the text is taken as adopted. We shall now enter on the discussion of the 3rd summary, worded as follows :

To prevent excessive tare weight, it is desirable that the body should take part of the stresses.

Coaches built on this principle are very little heavier than coaches with wooden bodies offering the same standard of comfort.

Mr. Lancrenon (in French). — At the beginning of the Meeting, I gave a summary of the records taken in different countries on the tare weight of coaches. I do not think there is anything to add.

As regards the last paragraph : « Coaches built on this principle are very little heavier than coaches with wooden bodies offering the same standard of comfort », one only has to look at the tables to recognise that we have succeeded in getting only very slight increases in weight, speaking generally of 4 to 5 % higher than that of wooden coaches of similar design.

Mr. Dähnick (in German). — I ask that the summary be drawn up in a wider form. The metal coach is not always heavier than the wooden one, but is often, from our experience, lighter. I therefore suggest that the summary be modified somewhat, as follows :

« Coaches built on this principle may be lighter or only slightly heavier than wooden coaches of the same capacity and arrangement. »

Mr. Lancrenon (in French). — Mr. Dähnick is comparing the metal coaches he has built with the wooden coaches of a previous construction; the latter were particularly heavy; they had been strengthened considerably and many metal parts had been incorporated in them. This is the reason why metal coaches may be said to have been built in Germany lighter than wooden ones.

To meet Mr Dähnick's views, I think we could word the second paragraph of summary 3 as follows : « Coaches built

on this principle have a tare weight very little different from... ».

Mr. Dähnick (in German). — I agree with that amendment.

The President (in German). — Do we accept the amendment proposed by Mr. Lancrenon and agreed by Mr. Dähnick ?

— The amendment was adopted.

The President (in German). — We will now take summary 4 :

In this form of construction it is possible to combine rolled sections, bent and pressed flat plates, cast steel and malleable iron castings.

In every way metal construction lends itself to the mass production of standardised parts.

Mr. Vallancien, *Reporter* (in French). — The French railways are using light metals as well. In these circumstances we could add to the first paragraph... « malleable iron castings and also light metals and alloys ».

Mr. Fraile, *Reporter* (in French). — The North of Spain Company has similarly used aluminium, but found that corrosion occurred. I should like to know if other Administrations make use of aluminium.

Mr. Leroy, French Nord Ry. (in French). — The French Nord System, has used aluminium in the construction of its metal coaches in the form of sheet aluminium and of alpax. No corrosion has been observed.

Mr. Bloch, Paris-Orleans Ry. (in French). — The French systems, especially the Orleans Company, have used aluminium sheets and aluminium alloys such as duralumin.

We found no corrosion when the duralumin was simply exposed to atmospheric influence, but corrosion takes place where the duralumin and the aluminium are in contact with magnesian cements, such as terrazolith; in such cases it is necessary to separate them by plinths of wood or some other chemically inert substance.

Mr. Legrand, French Est Ry. (in French). — In the trials carried out by the French Est Railway Company, with duralumin plates, we found corrosion at the points where the foot warmer covers were in contact with the wood.

Mr. Dähnick (in German). — Our point of view is that the trials so far made have not given such results as would allow us to say definitely which parts could be made of aluminium.

At the present moment we are carrying out an experiment on a large scale. It consists in building for the Metropolitan of Berlin a train of 8 coaches in which aluminium will be used as far as ever the design allows.

The President (in German). — We ought to decide if at the end of summary 4 there ought to be an addition relating to the use of aluminium.

Mr. Lancrenon (in French). — I propose to add a third paragraph which might run thus : « To reduce the weight of metal coaches, several administrations have used light metals and alloys to a greater or less extent. »

We shall thus put the fact on record without making any recommendation one way or the other.

All the same, I think it is interesting to note that aluminium is even now being used. This was the case with the coaches shown by the French Nord Com-

pany at the Decorative Arts Exhibition in 1925 — coaches in which 3 tons of aluminium or its alloys were used. Even at that time this was an extensive use of aluminium.

Mr. Bloch (in French). — We might perhaps express the wish to see attempts made towards reducing the weight of coaches and with this object, either to increase the proportion of light alloys or that of high duty alloys.

Mr. Lancrenon (in French). — I do not see anything against that; we might say finally :

« In order to lessen the weight of metal carriages, several administrations have carried out trials with high resistance steels and light alloys. The Congress recommends that the study of the use of these metals should be continued. »

At the President's request the Meeting agreed to the addition proposed by Mr. Lancrenon to the original article 4.

Mr. Lancrenon (in French). — We pass on to summary 5 :

Assembly can be done by means of rivetting, oxy-acetylene welding, arc or spot welding, or by a combination of these methods.

The President (in German). — Does anyone wish to speak on summary 5 ?

Mr. Leroy (in French). — The French Nord System, when building its metal coaches, made considerable use of welding, either electric spot welding or arc welding. Such encouraging results have been obtained that the Company hopes to be able to give up all rivetting in the construction of its coaches if the design of metal stock will allow it.

Mr. Fraile (in French). — I quite agree with Mr. Leroy in saying that electric arc or spot welding gives very satisfactory results for construction work, but as soon as a coach comes in for repair, as soon as it must be taken to pieces again, it is extremely difficult to work when there are no rivets. What is the experience of the Nord Company from this point of view ?

Mr. Leroy (in French). — In answer to Mr. Fraile's remarks two cases may occur : either the repair necessitates a major surgical operation, and in this case there can be no hesitation, the only thing to do being to cut away the defective part and to build it up again by the same welding methods; or else the damage is local in which case no difficulty arises.

One of our coaches, through an accident, had one of its panels badly bulged, without its being penetrated. All that was needed was to apply heat to the distorted place, to hammer it back and to weld up again those parts which had given way during the straightening out process.

We have experienced no difficulties with regard to this.

If the panel had been rivetted we should have done the work the same way without taking down any parts. Furthermore experience shows that after a certain time, rivets become very hard to cut out and the flame has to be used. The same method is always used and it is as easy to cut away a welded section as one which is rivetted.

The President (in German). — It seems to me that we may now adopt the text of the 5th summary as proposed by Mr. Lancrenon in his special report.

We now pass to summary 6.. A short

time ago we agreed to combine summary 2 with it, beginning with No. 6.

We shall therefore have the following:

The interior can be fitted out in the same way as wooden vehicles. They can, however be given a novel appearance if the metal plates are left visible and the interior decoration treated accordingly.

Metal coaches can be fitted up so as to assure to the public a degree of comfort equal, and even superior, to that of vehicles with wooden bodies.

Mr. Lancrenon (in French). — On the subject of the interior decoration of metal coaches, two theories have been formulated which are in direct conflict with one another, and this perhaps is the sole point on which the reporters are not in entire agreement.

Certain reporters, Mr. Lemon among them, thought it extremely desirable that passengers should not realise that they were in a metal coach.

I do not quite agree with Mr. Lemon and I must point out that the Sleeping Car Company which hitherto has used metal coaches lined inside with wood has, in the latest coaches just put into use, broken away from its former methods. The latest type of coach constructed by this Company is like the coaches of the French Nord Railway, lined inside with sheet metal, left visible on the inside partitions.

Mr. Fraile (in French). — I feel some hesitation in subscribing to the summary — the original No. 2 — which says that « metal coaches can be fitted up so as to assure to the public a degree of comfort equal, and even superior, to that of vehicles with wooden bodies », for if metal coaches are used in a country with very high temperatures, or subject to great variations of temperature, we are certainly likely to meet with difficulties.

During the winter season we can doubtless make up for the fall of the outside temperature by adequately heating the interior, but on the other hand we are powerless before the great heat of summer, and in regions like Andalusia it may become impossible to travel in summer time in metal coaches.

So far as I know, this is the reason why Portugal scarcely ever uses metal coaches, or at least has not had favourable results from such.

Similarly, in Egypt, all-metal coaches are scarcely used, and they are now trying to find a paint which will give sufficient insulation to maintain a suitable temperature inside the coach.

Consequently we ought to modify the original summary 2 slightly and make a reservation so far as hot countries are concerned.

The President (in German). — Does any one wish to speak ?

Mr. Dähnick (in German). — The Deutsche Reichsbahn has gone into the question to see if it were wise to use coaches in which only metal was used. We have proved that wood makes a better thermic insulator and, besides, that it deadens sound. That is why we now prefer to line out the vehicles in wood.

Mr. Vasconcellos Correia, Portuguese Railway Company (in French). — A propos of what Messrs. Fraile and Dähnick have just said, I would add that in Portugal we have used metal coaches, but fitted with wood inside. Besides, our temperatures are not as high as those of Andalusia or Egypt : In Portugal therefore, there is no question of giving up the use of metal coaches as these have many advantages.

Mr. Bloch (in French). — In France. the Paris-Orleans Company has paid especial attention to questions of comfort and particularly to the inside temperature of the coaches.

Even with wooden coaches which had been standing outside in an atmospheric temperature of about 32 to 35° (90 to 95° F.), heating up occurred, and we got inside temperatures of certainly round about 40° (104° F.).

The Orleans Company has adressed an enquiry to all the railways in the world in equatorial regions with the view of ascertaining the means employed by those railway companies to protect passengers against the heat, particularly in the Dutch East Indies, the Soudan, Egypt and America. A certain amount of interesting but inconclusive information has been received. The Company has made a thorough study of the subject and installed, last year, an arrangement in a trial coach by which cooled air which has passed over a refrigerator is circulated in the passenger compartments. The fan required for circulating this air does not take more than 400 watts.

The method considered is analogous to that used in Aemrica to cool theatres. The experiment was quite successful. I think it might be used with advantage to increase the comfort in the metal coaches now being built.

The President (in German). — I wonder if from the point of view of procedure it would not be as well to change somewhat the order of the sentences in the combined summaries 6 and 2.

Would it not be better to start with the first sentence of No. 6, then No. 2 in its entirety, which would be followed by the last part of No. 6. « they can however... ». The draft should be modified consequently. I submit the matter to Mr. Lancrenon.

Mr. Lancrenon (in French). — On account of the observations of Mr. Fraile and other delegates, as well as those which Mr. Gresley has refrained from making so as to save time, it would be as well to change the original summary 2 somewhat and redraft it in a rather less absolute way; we could put, so as to avoid the extremely hot countries which, after all, are the exception: « In the majority of cases, metal coaches can be so fitted up so as to assure to the public *a degree of comfort equal* » instead of putting « *equal, and even superior*, to that of vehicles with wooden bodies ».

Otherwise, I have no objection to the change in the order proposed by the President.

Mr. van Schouwenburg (in French). — I am sorry that we have not among us a representative of the Dutch East Indies State Railways, who could give us the benefit of his experience on this subject. In the Dutch East Indies the mean yearly temperature is as high as 30° C. (96° F.). We use all-metal coaches the roofs of which are painted white. The results are satisfactory.

The President (in German). — I think we can adopt summaries 6-2, which now become summary 5, almost in the form proposed by Mr. Lancrenon, to wit :

« 5. The interior can be fitted out in the same way as wooden vehicles. They can however be given a distinctive appearance if the metal plates are left visible and the interior decorations treated accordingly. In most cases metal coaches can be fitted up so as to assure to the public a degree of com-

fort equal at least to that of the vehicles with wooden bodies. »

No objection being raised I take it that the Meeting approves of this draft.

We now comes to summary 7 of the original text, which now becomes summary 6 and which reads as follows :

The methods of construction are still too varied and the vehicles on numerous railways have been put into service too recently to allow precise conclusions to be formed regarding the first cost of construction, and the repair charges.

Mr. Koller (in French). — I quite understand that we cannot have exact details of upkeep and first costs but seeing that in several countries metal coaches are only just being introduced, it would be appreciated if the delegates representing administrations and companies who have been running metal coaches for some years past, would make a comparison between the upkeep of these coaches and of wooden ones both from the standpoint of running repairs and also of repairs consequent on damage due to accidents.

Mr. Lancrenon (in French). — Mr. Koller puts a question which is very difficult to answer.

On the European Railways, it is barely ten years at the most since metal construction was introduced and some railways, those in France for example, only started it seriously 5 years ago. Consequently we are not able to give exact information.

With this reservation, since Mr. Koller has been kind enough to ask my opinion, I think that :

1. From the point of view of current upkeep, the cost is the same for a metal coach as for a wooden one.

2. In the case of damage, assuming it is of equal extent, repairing a metal coach costs more than a wooden one.

But as under the same circumstances the metal vehicle would have been less seriously damaged than the wooden, the advantage rests definitely with the metal coach.

3. Finally, a wooden coach must be thoroughly overhauled at the latest 10 to 15 years after leaving the shop new, whilst a metal coach could go, as far as can be foretold and assuming good maintenance while in traffic, about 20 or 30 years; the future alone can prove this.

Perhaps Mr. Dähnick can give us more precise information ?

But I think that the real advantage of metal construction, from the point of view of cost of upkeep of the coaches, is that it postpones the need for the first general overhaul and increases the intervals between succeeding ones.

Mr. Dähnick (in German). — I am absolutely at one with Mr. Lancrenon. Our experience teaches us that many of the minor injuries of wooden vehicles are avoided with metal ones.

Mr. André, *Vice-president* (in French). — We could complete the summary by adding that, judging by experience gained, good results may be anticipated.

Mr. Lancrenon (in French). — We could add at the end « Results so far obtained, however, are encouraging ».

The President (in German). — No objection having been raised the addition proposed by Mr. Lancrenon is adopt-

ed, and we pass to the original summary No. 8 :

Numerous experiments have still to be made both as to the choice of the methods of construction and the materials to be used, as in fitting out the interior, such as the insulation of the body sides, the floor covering, interior linings, painting, and protection of the plates against rust.

Mr. van Schouwenburg (in French). — Does the term « insulation » include protection against heat ?

Mr. Lancrenon (in French). — Yes, against heat and against cold. I see no reason for not employing the expression « heat insulation ».

Mr. Vallancien (in French). — Certain French Railways believing that the only danger to which passengers remain exposed in the event of collision is from broken glass, would like to add to the subjects to be investigated: glass of greater strength or glass which will not fly into splinters when broken.

Mr. Dähnick (in German). — We also have to complain about broken glasses. We are now using very strong frames and the number of breakages has noticeably diminished.

Mr. Vallancien (in French). — In France we also have fitted frames that should avoid breakages during ordinary working. But there still remains the question of safety in case of accident — safety which would be increased by the use of non-splintering glass.

The President (in German). — I propose to complete the new No. 7 of the summaries by an addition relative to glass breakages. We will leave to the Principal Secretary the task of drafting the exact text.

The discussion of question VIII is thus finished and it now remains for the 2nd Section to decide what questions within its purview it wishes to put forward for investigation during the next Session of the Congress.

We must choose three of the following :

1. Mechanical stokers for locomotives. Use of pulverised coal and liquid fuel.

2. Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

3. Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

4. All-metal rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogeneous welding.

Sir Henry Fowler, London Midland & Scottish Railway. — I wish to propose a new text to replace the wording of the second question which is too concise, with the object of making the nature of the subject more explicit, thus :

« To consider the best methods to be employed in order to increase the distance locomotives can run between heavy repairs and to ensure as large a percentage of the locomotive stock being available for traffic purposes as possible. ».

Mr. Bianchi (in French). — I suppose steam locomotives only are to be considered ?

Sir Henry Fowler. — It is for the Meeting to decide the types of locomotives to be gone into. There is noth-

ing in the text which limits the types to be considered, to steam locomotives alone.

Mr. Koller (in French). — I quite agree with this suggestion.

Perhaps it would be as well to give a wider scope to the first question by saying for example « progress made more particularly in the steam locomotive. »

In this way we should have to discuss at the next Congress the very important questions which we have just considered : « New types of locomotives, improvements in steam locomotives of the ordinary type »; we could thus ascertain the progress which will certainly have taken place during these three years.

The President (in German). — In accordance with the wish of the Permanent Commission, we should first of all eliminate one of the four questions I have just read.

— In order to prevent misunderstanding, the President again read over the proposed questions, remarking that Sir Henry Fowler had suggested a more detailed text for question 2.

Mr. van Schouwenburg (in French). — Is it not possible to combine the first two questions? The mechanical stoking of locomotives may be considered as one of the steps to take towards increasing the mileage.

Sir Henry Fowler. — No. 2 : « To consider the best methods to employ in order to increase the distance locomotives can run between heavy repairs and to ensure as large a percentage of the locomotive stock being available for traffic purposes as possible » is put forward on my suggestion, and it is not, I think, the same question as Mr. Bianchi has in mind.

Mr. Koller (in French). — We shall certainly select the question of electrification, and then that dealing with metal construction, so that there remain the two questions relating to the steam locomotive. My own opinion is that it would be preferable to combine the two questions in one, bringing out the progress made in the construction, otherwise I should be inclined to widen the scope of question 2.

The President (in German). — The four questions submitted to us were drawn up by the Permanent Commission. We cannot therefore make any changes and should confine ourselves to considering which of the four should be cut out.

Sir Henry Fowler. — I suggest that the subjects be those given in Nos. 2, 3 and 4. With regard to No. 1, this might be divided into two parts, one being the mechanical stoker question, with regard to which the Americans have great experience, and the second dealing with pulverised fuel. I wish to point out that, with regard to the second part of the question, it would be necessary to get out a questionnaire in about a month's time, and I think everybody will agree that there would be available very little information, and that not spread over a wide range, by the time the questionnaires were returned. I therefore, think it would be of considerable advantage if the Section agreed to Nos. 2, 3 and 4.

The President (in German). — That then is a formal proposal to leave question No. 1 on one side.

Mr. Collin, French Nord Ry. (in French). — I do not at all concur with Sir Henry Fowler. It seems to me that

the second question is one which depends greatly upon the particular running conditions of each system, and that its scope is not general enough to be discussed at a Congress.

On the other hand, the first question is of a much more general nature. It is true that we have not, at the moment, the same reasons for having mechanical stoking as our American colleagues, but it is possible that in the not-too-far-distant future we may be brought to it, and consequently it would be interesting to be informed of what is done abroad from this point of view.

So far as I am concerned therefore, I propose that we take the first, third and fourth questions and leave the second.

Mr. Wagner (in German). — I have looked at these four questions from another aspect.

The first question seems to me very interesting from the point of view of construction. Its study would provide us with details which certainly would be of the greatest use in the future.

The second question seems to me equally important as regards the work done by the whole locomotive stock — electric no less than steam.

The study of the third question relating to the electrification of railways from an economic point of view may also bring out totally new aspects of the subject.

On the other hand, the fourth question is generally similar to the one we have just examined; consequently it is doubtful whether a space of three years can show great improvements in this matter and it would seem to me more logical to postpone this question to the Agenda of some later Session.

Mr. Koller (in French). — I support Mr. Wagner.

Mr. Lancrenon (in French). — I would like to point out that the question as it stands, does not deal only with metal carriages; it deals with both carriages and wagons. It is therefore quite a different question from that which we have been examining today and I am for retaining it.

Mr. Vallantin, Paris, Lyons & Mediterranean Ry. (in French). — I should like to raise the following question :

The reporters who will have to make the reports which will be presented in three years time will have to send out their questionnaires at the latest within six months or a year from now. In six months or a year how many mechanically fired locomotives will there be in Europe ? How many locomotives will there be burning pulverised coal ? How many will there be burning liquid fuel ? I believe that the number will be very small and that the reporters will not be able to let us have sufficient data.

Mr. Wagner (in German). — The locomotive designer at the present time is asking himself how the firebox should be built, especially where big units are concerned. Ought he to adopt the mechanical stoker or ought he to anticipate the use of pulverised coal ? After all it is not the number of locomotives which is important, but rather the design of locomotive. It would be extremely interesting to have information on these question even if only a few odd locomotives were concerned.

When we were considering the electric locomotives, it was not the locomotives represented by the greatest number of units which interested us the most, but

rather the very latest types, which obviously formed the minority.

I ask you therefore not to set on one side the first question as it is a very important one as regards the future development of the steam locomotive.

The President (in German). — It seems to me that we are all agreed in retaining question three.

Mr. Vallantin (in French). — I quite agree with Mr. Wagner that it would be very interesting to have particulars of locomotives burning powdered coal, of locomotives using liquid fuel, and of mechanical stokers; but I repeat, we wonder who can provide us with sufficient data.

Sir Henry Fowler. — I beg leave to suggest that the matter be now put to the vote, and that the numbers who object to the various questions be recorded. — This was done and the results were :

The majority having voted against question I, it was deleted and questions 2, 3, and 4 remain on the Agenda for the next Session.

The President (in German). — The Agenda of the second Section has been dealt with, unless some one still wishes to speak.

Sir Henry Fowler. — I propose that a hearty vote of thanks be given to the President for his presence in the Chair of the 2nd Section. I cannot but feel that this has not been an easy Section to deal with, but the results have shown that the Delegates have taken an interest in the work which has been done. I feel sure that someone else will like to support me in this. *(Applause.)*

Mr. Bianchi (in French). — I believe I am voicing the feelings of all my colleagues, and especially of the reporters, in offering our warmest thanks to the President, the Vice-Presidents, the Principal Secretary, the Secretaries, Dr. Velleman as well as to the translators and stenographers. *(Applause.)*

The President thanked the Assembly for its sustained interest and in particular expressed his thanks to the delegates who spoke during the discussions.

— The meeting then ended.

DISCUSSION AT THE GENERAL MEETING.

Meeting held on the 15 May 1930 (morning).

President : Mr. José GAYTAN de AYALA.

General Secretaries : Messrs. P. GHILAIN and A. KRAHE.

Assistant General Secretaries : Sir Henry FOWLER, K. B. E., Messrs. P. WOLF and J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary.* — The text of the summaries adopted by the 2nd Section on the subject of question VIII appeared in the *Daily Journal of the Session.*

The President. — Has any one any remarks to make ?

Mr. van Schouwenburg, Dutch East Indies Railway Company. — In article 7 of the summary of question VIII « insulation of the body sides » is spoken of. It would be better to say « heat insulation ».

Mr. Ghilain. — I take it we may consider that modification as adopted

The President. — The summary is as follows :

Summary.

« 1. In those countries in which the « operating conditions permit the con- « struction of all-steel carriages, exper- « ience has shown that conditions of sa- « fety sufficiently justify the adoption « of this construction for new stock.

« 2. To prevent excessive weight, it is « desirable that the body should take « part of the stresses.

« Coaches built on this principle have « a tare weight very little different from « that of coaches with wooden bodies « offering the same standard of comfort.

« 3. In this form of construction it is « possible to combine rolled sections, « bent and pressed flat plates, cast steel « and malleable iron castings.

« In every way metal construction lends « itself to the mass production of stan- « dardised parts.

« In order to lessen the weight of me- « tal carriages, several administrations « have carried out trials with high ten- « sile steels and light alloys. The Con- « gress recommends that the study of « the use of these metals should be con- « tinued.

« 4. Assembly can be done by means of « rivetting, oxyacetylene welding, arc or « spot welding or by a combination of « these methods.

« 5. The interiors can be fitted out in « the same way as wooden vehicles. They « can however be given a distinctive ap- « pearance if the metal plates are left « visible and the interior decorations « treated accordingly. In most cases me- « tal coaches can be fitted up so as to « assure to the public a degree of com-

« fort equal at least to that of the ve-
« hicles with wooden bodies.

« 6. The methods of construction are « still too varied and the vehicles on nu- « merous railways have been put into « service too recently to allow precise « conclusions to be formed regarding the « first cost of construction and the re- « pair charges. Results so far obtained « however have been encouraging.

« 7. Numerous experiments have still « to be made both as to the choice of the « methods of construction and the mate- « rials to be used in fitting out the in- « terior, such as heat insulation of the « body sides, the floor covering, interior « linings, breakage of glass, painting, and « protection of plates against rust. »

— The General Meeting ratified this summary.

MISCELLANEOUS INFORMATION.

[625 .144.4 (.42)]

1. — New London and North Eastern Railway track-laying machine.

Fig. 1, p. 168.

(*The Railway Gazette.*)

The London & North Eastern Railway have recently placed into service a track-laying train manufactured by Herbert Morris Limited, of Loughborough. This is the first train of this kind to appear in Britain and consists of a power van, a saw trolley, a train trolley, and the track-layer proper.

The power van consists of a 72-B. H. P. pe-

Fig. 1. — New section of track on the London & North Eastern Railway, ready to be pulled into position by Morris track layer.

trol-driven generating set which provides the electric current for the various motors operating the track-layer, together with the necessary switchgear. The saw trolley consists of two circular saws mounted on a four-wheeled truck and so arranged that it cuts the ends of sleepers simultaneously as the track is moved along; the saws are operated by a 40-B. H. P. motor. The track-layer proper is a 12-wheeled vehicle on which is mounted a cantilever crane.

The train trolley runs not on the track itself, but on rails fixed to the wagons forming the materials train, linked together in such a was as to provide a continuous run from one end of the train to the other. The materials train is loaded at the depot with rails already fixed to chairs and sleepers and, on arrival at the section which is to be relayed, the first operation is for the saw trolley to run over it and cut the sleepers down to a uniform length, 8 ft. 6 in.; this is done without removing the track. The fish plates joining one section of rail to the next are removed and the cantilever on the track-layer lifts the complete section up, places it on the train trolley, which then carries it back along the train, drops it and returns with a new section. The new section is lowered to the track and the whole train advances over it, and the next section similarly dealt with. The object of the apparatus is to speed up track-relaying work.

A complete illustrated description of the Morris track-laying machine was published in the 20 July 1928, issue of *The Railway Gazette* (1), and figure 1 shows the train at work on a section of the London & North Eastern Railway.

[**621**. 392 (.**42**)]

2. — Electric welding in railway work.

Figs. 2 to 4, p 170.

(*The Railway Gazette.*)

Recent years have witnessed rapid developments in the employment of welding in the engineering industry. Railway engineers and private firms engaged in the production of railway equipment have not been slow to take advantage of the many improvements introduced by welding equipment manufacturers as a result of their increasing experience and research. At the same time, of course, there are still engineers who place greater confidence in the riveted rather than the welded joint, but as further experience is obtained there seems little doubt that the employment of welding will become increasingly popular.

As an instance of what is at present being done in locomotive building and repairing work, the following list of jobs hitherto riveted or secured by studs and nuts, etc., but now welded, with, it is considered, equally good results, may be cited : Boiler seams and foundation rings, main steam pipes, frame angles, smokeboxes, combustion chambers, cab details, brackets, sand boxes, coupling and connecting-rod oil cups, etc. In America, where development has hitherto perhaps been more widespread, there are instances of complete locomotive tender bodies, including tanks, bogie tables, brake hanger brackets, footsteps, etc., being completely welded together without the necessity for any riveting whatsoever. Very considerable saving in weight secured by the elimination of angle iron and other rivet details by the new method will be obvious, and it is principally in this direction rather than in the greater strength or reduced production time that the advantages of welding are to be found.

During a recent visit to the Walthamstow works of Alloy Welding Process Limited we were enabled to inspect some interesting examples of welding by the electric process in conjunction with this firm's well-known

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(1) See also *Bulletin of the Railway Congress*, August 1926 number, p. 766.

Fig. 2. — Welded solebar, headstock and diagonal after drop test.

Fig. 3. -- Welded steel trough sleeper and fastening for flat-bottomed rail.

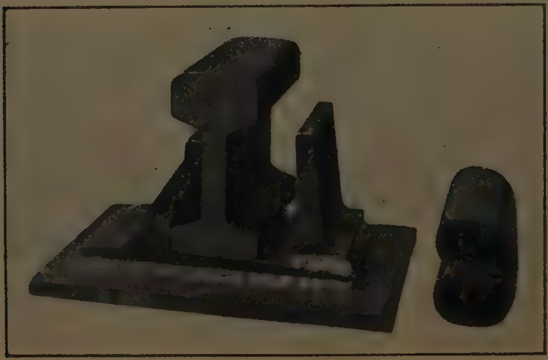

Fig. 4. — Steel sleeper with welded chair for bull-headed rail.

« A. W. P. » electrodes. The generally accepted theory that to obtain similar steels in the deposited metal it is only necessary to employ steel of corresponding analysis as the electrode core with a suitable asbestos winding or other flux is reversed in the process under notice. Here the asbestos winding serves principally to bind the flux compound to the surface of the wire.

In the case of electrodes for welding mild steel, the flux compound need only be of such a nature as to act as a deoxidiser. This alone would ensure the weld metal being homogeneous, free from porosity and to recognised mechanical standards. When, however, it is desired to produce electrodes to suit an alloy steel of known analysis, A. W. P. employ special metals in powder form, which are mixed with the flux, prior to extrusion. Extreme accuracy is required in this operation, both as regards the percentage of metals included, and also to ensure intimate and uniform mixing. These metals, incorporated in the flux coating, can be varied at will during manufacture to suit the analysis of the steel to be welded. During the welding operation, the covering of the electrode melting at the same speed as the core imparts into the small pool of molten metal at the arc the correct proportion of special metals, which have been conveyed across the arc, thereby utilising the arc as a miniature electric furnace to manufacture alloy steels.

The action closely follows out the principles adopted by the steel maker. There is, however, an important action taking place at the arc and relating to the losses which occur in the special ingredients whilst crossing the arc. These losses have been attributed to the high temperature of the arc causing a percentage of the special ingredients to be given off as gases.

We were particularly interested during our inspection of the works at Walthamstow to note the method there adopted and the successful results obtained in connection with the welding of railway carriage and wagon underframes. An underframe solebar head-stock and diagonal, as shown in figure 2, which had been welded together by the A. W. P. process, was subjected to a series of severe tests. A falling weight of 13 cwt. was used, and the two blows, from heights of 1 foot and 2 feet respectively, were taken by the corner of the projecting diagonal. After the first blow the angle of the diagonal was reduced from 75° to 60°. The second blow, however, not only caused the angle to be still further reduced as from 60° to 23°, but the flange of the channel after stretching and reducing its thickness by 30 % fractured down to the root.

In the case of test No. 2 the weight was allowed to fall from a height of 6 feet directly on the corner of the frame, when it was found that the welding of the gusset plate to the solebar was slightly cracked. A second similar blow, but from a height of 10 feet, caused the crack to open out for a distance of 3 inches (out of a total length of 11 inches), but beyond this point the weld held and actually a portion of the web of the channel solebar was torn away. At no other point did the welding show the slightest crack or sign of failure although the channels were badly distorted, buckled or stretched.

It should be mentioned that the parts were merely welded together to show the proposed method of construction, and it was not decided to test the specimen until after the welding had been carried out.

It is estimated that the weight of a welded frame will be approximately half a ton less than that of an ordinary riveted frame, and sufficient data is available to show that when the work is done under mass production conditions, the actual costs will be in favour of the welded construction.

During the last three or four years a large number of steel sleepers having electrically welded bearing plates have been laid on the German Railways, and the type of sleeper has since been recognised as standard. Figure 4 shows a section of steel sleeper with welded chair for bull-headed rails, and a similar welded steel trough sleeper and fastening for a flat bottom rail is illustrated in figure 3. This method of construction is claimed to have the following advantages :

1. The sleeper has no holes from which cracks and corrosion start and through which

grit and moisture find their way, and therefore the shell is not weakened at the very place where the greatest strength is required, *i. e.*, in the vicinity of the rail seat.

2. The absence of holes and the additional strength afforded by the bearing plates enable the thickness of the top of the sleeper to be reduced, and in certain types of sleepers sufficient weight is saved to cover the cost of providing and welding the two bearing plates.

3. The faces of the plate and the sleeper which are in contact are hermetically sealed; moisture and grit cannot enter and therefore corrosion and abrasion between those faces are entirely eliminated.

NEW BOOKS AND PUBLICATIONS.

[621 .33]

ELECTRIFICATION OF STEAM RAILROADS COMMITTEE (U. S. A.). — **Electrification of steam railroads.** — New York, National Electric Light Association, 24, Lexington Avenue. 1 pamphlet (8 1/4 × 11 1/2 inches) of 72 pages, 55 figures in the text (Price : $1.50).

This pamphlet contains the annual report for 1930 of the National Committee set up in the United States to investigate from the statistical and economical aspects railway electrification problems with the object of bringing out the mutual interest of the railways and the power companies and to act as a connecting link between these two great industries. These industries have an equal number of representatives on the Committee.

The report first of all gives an account of the work done by the Committee during the last year.

The Committee has kept contact with most of the electrified railways through the world, and has prepared statistics which are condensed into a number of tables giving for each country and for each railway the length of lines electrified, the system of electrification, the kind of traffic, the reasons for electrifying and the results obtained. A second series of tables gives technical details of the lines electrified and of the motor and trailer stock used.

An important chapter of the report is devoted to recent progress in electrification in the different countries. It describes first of all the extensions of electrification carried out by different United States railways and of projected electrification under consideration. It then reviews all countries in which railways made provision in 1929 for large expenditure on electrification. The European countries and especially France, England, Germany, Spain, Sweden and Switzerland are dealt with specially in paragraphs giving information on recent progress, new railway stock, and schemes in hand, all of which make the report unusually interesting to the European reader.

The Committee appointed two subcommittees, the reports of which are given as appendices. The first of these reports deals with the form of contract adopted by the United States Companies for power supply to the electrified lines. The second report deals in great detail with the electrification of the railways in the Western States : the Butte, Anaconda and Pacific Railway, the Chicago, Milwaukee, St. Paul and Pacific Railway, and the Great Northern Railway.

The first two have been electrified for some years whereas the electrification of the third was only completed in 1929. Each of the three chapters contains a historical note, a description of the lines electrified and of the locomotives employed, an analysis of the contracts for power supply, a consideration of the questions affecting maintenance of the lines, and a review of the operating results; this part is copiously illustrated by maps, diagrams and photographs.

This report forms in fact a fully documented, statistical and economical annual on electrification questions on the railways of the whole world.

A. C.

[385 (06.111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

of the International Railway Congress Association.

Meeting of the Permanent Commission held on the 18 October 1930.

The Permanent Commission of the International Railway Congress Association met on the 18 October last at the Headquarters Offices of the Belgian National Railway Company at Brussels, Mr. E. FOULON being in the Chair.

The Meeting unanimously re-elected those members of its Executive Committee who were in office, and nominated as member of this Committee Mr. D. VICKERS (already member in the Permanent Commission) in place of Mr. Gustav BEHRENS who had resigned.

Furthermore, Messrs.

D. CHREPLOVITCH, general manager, State Railways of the Kingdom of Yugoslavia;

A. J. DAY, consulting engineer to the Office of the High Commissioner for the Union of South Africa, and

L. VELANI, vice-general manager of the Italian State Railways,

were made members of the Permanent Commission, respectively in place of Messrs. DJOURITCHICH, von WILLICH and FABRIS who had resigned as a result of changes in their official positions.

The Meeting alloted a mandate of member of the Permanent Commission to Bulgaria and 2 additional mandates to Canada.

It was, moreover, decided that members of the Permanent Commission who reside outside Europe and find it difficult to make the journey to Brussels in order to attend the meetings of the Permanent Commission may henceforth be represented by a delegate belonging to the railways.

The Madrid Congress having decided that the 12th Session is to be held at Cairo in 1933, the Belgian Government, through the usual diplomatic channels, has requested the Official agreement of the Egyptian Government [1].

Abdul Hamid SOLIMAN Pacha, who was unable to attend the meeting had delegated Yussef RISGALLAH Bey, Secretary to the Egyptian Local Organising Committee, who outlined to the Permanent Commission the arrangements proposed for the organisation of the Session.

I was deemed desirable that the Cairo

(1) The Egyptian Government has since notified its agreement.

Congress should be opened between the 10 and the 16 January 1933.

The list of the questions to be brought up for discussion at the 12th Session had been drawn up at the Madrid Congress; the Permanent Commission consequently proceeded with the distribution of the mandates of reporter between the various countries (1).

Several other questions were also considered, namely a new contract for the printing of the three editions of the Monthly *Bulletin* of the Association and an addenda to the agreement with the advertising agents of the *Bulletin*, securing to the Association an appeciable increase of receipts, beginning with the year 1931.

* * *

The following changes have taken place in the membership of the Association since the last meeting.

A. — GOVERNMENTS.

The Management of Public Works of the Spanish Protectorate in Morocco has been affiliated to the Association.

B. — ORGANISATIONS.

The Permanent Commission also approved the affiliation to the Association of the Permanent Committee for Railway Transportation, of the League of Nations.

C. — ADMINISTRATIONS

Admission.

Portuguese Company for Railway Construction and Operation, Linhas do Vale do Vouga . 176 km. (109 m.)

Resignation.

Uddevalla-Venersborg-Herrljunga Railway (Sweden). . . . 92 km. (57 m.)

The Railway Congress Association at the present time (18 October 1930) includes 234 Administrations operating railways of a total length of 625 352 km. (388 583 miles).

P. Ghilain,
General Secretary.

E. Foulon,
President.

(1) The list of questions with the names of the respective reporters will be published in a next number of the *Bulletin*.

Appendix to the Official Documents

Abstracts from the Proceedings of the Meetings held by the Permanent Commission of the Association in Brussels on the 15 February 1930 (preparatory to the 11th Session and in Madrid on the 5 and 14 May 1930.

A. — Alterations in the composition of the Permanent Commission.

(Meeting held on the 15 February 1930.)

M. Gustav BEHRENS, who had resigned, was replaced by Mr. D. VICKERS, director, London Midland & Scottish Railway.

Mr. KUNZ, deceased, was replaced by Mr. A. MARGUERAT, manager of the Viège to Zermatt, Furka-Oberalp and Schöllenen Railway Companies.

The new seats on the Permanent Commission alloted to the Argentine Republic and to New Zealand were conferred respectively upon Messrs :

F. CASTELLO, director general of railways, Ministry of Public Works, Argentine Republic, and

R. J. HARVEY, consulting engineer to the Government of New Zealand.

Mr. A. MANGE, already member of the Permanent Commission will henceforth represent one of the affiliated Organisations (International Railway Union) on the Permanent Commission, and

Mr. A. HENRY-GRÉARD, manager of the Paris-Orleans Railway Company will take Mr. Mange's place as the representative of that Company on the Commission.

Meeting of the 5 May 1930.

Sir Ernest Albert Seymour BELL, Sir Guy GRANET, and Mr. T. HIRAYAMA, who resigned, were replaced respectively by :

Sir Frederick PALMER, C. I. E., consulting engineer, Office of the High Commissioner for India;

Mr. H. N. GRESLEY, chief mechanical engineer, London & North Eastern Railway, and

Mr. N. YUMOTO, secretary to the Japanese Ministry of Railways and manager of its Berlin Office.

The membership of the Permanent Commission alloted to Portugal, was conferred on Mr. R. da COSTA COUVREUR, chief engineer, Way and Works Division, General Directorate for railways, member of the High Council for Railways, Portugal.

Messrs. P. BOIX, managing director of the North of Spain Railway Company, and

L. MORALES, vice-President of the Spanish High Council for Railways, chairman of the Board of Directors of the Western of Spain Railways.

were elected members of the Permanent Commission to fill in the two additional mandates alloted to Spain.

Mr. J. GAYTAN de AYALA, former president of the Spanish Council for Public Works, having presided over the 11th Session of the Congress, becomes member for life of the Permanent Commission.

B. — Changes amongst the member Administrations.

Admissions.

(Meeting of the 15 February 1930.)

	Kilometres.	Miles.
National Railways of Mexico	12 005	7 460
Rio Grande do Sul Railway, Brazil	2 610	1 622
Port and Railways of Lourenço-Marques (Portuguese Colonies)	257	160
Morocco Railway Company	579	360
Jamaica Government Railways	337	209
Borras-Herrljunga Railway, Sweden	127	79
Turkish State Railways	2 240	1 392

(Meeting of the 5 May 1930.)

Canadian Pacific Railway	23 847	14 818
National Railway Company, Colombia	116	72
Colombia Railways & Navigation Company	106	66
Cantabrico Railway Company, Spain	105	65
Asturias Light Railways, Spain	115	71

(Meeting of the 14 May 1930.)

Tranvie Ellettriche Bresciane Company, Italy	210	130

Resignations.

(Meeting of the 15 February 1930.)

Atlanta & West Point Railroad & the Western Railway of Alabama	352	219
Hocking Valley Railroad	552	343
Londonderry & Lough Swilly Railway	161	100